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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

INCLUDING THE

PROGRAMME OF THE

1957 SUMMER MEETING IN THE EAST

AT

NOTRE DAME, INDIANA

June 20–21–22

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June 20, 1957 Series II, Vol. 2, No. 5

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

1957 Summer Meeting in the East, Notre Dame, June 20–22, 1957

THE American Physical Society will hold its **1957 Summer Meeting in the East** at the **University of Notre Dame,** Notre Dame (near South Bend), Indiana, on Thursday, Friday, and Saturday, **June 20, 21, and 22, 1957.** This will be our first meeting at Notre Dame and probably our first in Indiana apart from the 1937 Annual Meeting in Indianapolis. Our Division of Electron Physics as heretofore makes this Summer Meeting its principal convention of the year and provides a large part of the programme both of invited and of contributed papers: invited papers have also been bespoken from the universities of Indiana and others of the nearby region. The Chairman of the Local Committee is Professor J. W. Mihelich, and to him we express our gratitude for the arrangements that he has made.

South Bend is on the New York Central and the "South Shore" (Chicago, South Shore and South Bend) which latter will be particularly convenient for those coming from or through Chicago; its trains follow the Illinois Central tracks in Chicago, starting from Randolph Street and stopping at Van Buren Street, Central Station, and Woodlawn (at 63rd Street near Dorchester). Notre Dame is on the Northeast edge of South Bend, about two miles North of the business district, and has as one of its boundaries U. S. 31; turn right at Angela Boulevard.

Hotels and dormitories. Dormitory accommodations will be available on the campus at $2 for singles and $3 for doubles: for these write to Professor J. W. Mihelich, Department of Physics, University of Notre Dame, Notre Dame, Indiana. There is a hotel on the campus, the Morris Inn (singles $9 to $12, doubles $12 to $19). In the neighboring city of South Bend there are the Hoffmann Hotel, the LaSalle Hotel, and the Oliver Hotel, all with somewhat lower rates, and a number of motels. Some of the rooms in the three last-named hotels are air-conditioned, and slightly more expensive: the air conditioning may be well worth the extra cost. Taxi fare from downtown South Bend to the University is about one dollar; about once in twenty minutes there is a bus taking ten minutes for the journey.

The **registration desk** will be in Room 102 on the ground floor of Nieuwland Science Hall. All members and guests are asked to register, and to pay the modest registration fee of one dollar. Banquet tickets will be sold at the desk, and nearby there will be blackboards for announcements of the post-deadline programme if any, of messages, and of any information that may be needful about matters not stated or wrongly stated in this Bulletin.

Invited papers on the programme of the Division of Electron Physics are by R. H. Good, Jr., P. Handler, D. W. Juenker, J. J. Lander, J. D. Morrison, E. E. Muschlitz, Jr., K. Watanabe, and H. F. Webster.

Invited papers on the general programme are by F. J. Blatt, C. P. Browne, G. B. Collins, H. Y. Fan, R. Gomer, L. C. Hebel, Otto Laporte, Riccardo Levi-Setti, D. I. Meyer, J. W. Mihelich, G. Parzen, A. Petrauskas, R. D. Spence, R. M. Steffen, B. Waldman, and J. C. Wheatley.

Sixty-eight contributed papers are distributed among nine sessions, four of the nine being in the province of electron physics.

The **banquet of the Society** will be held on Friday evening at seven in the University Dining Hall. The price has been set at $3.85, including gratuity. Buy your tickets as early as possible at the registration desk (a form for advance reservation will be found on the last page of this Bulletin); if you are delayed, keep an eye on the blackboards for notice of the closing time for sale of dinner tickets. The after-dinner speakers will be announced on the blackboards if not in this Bulletin.

The University will be host at a **cocktail party** at five on the same day.

For the ladies, a tea is being planned for Thursday afternoon. Before it, there will be a tour of the campus. Points of possible interest are the Art Gallery, Notre Dame Television Station, and the Lobund Germfree Animal Institute.

The **snack bar** in the Student Center, adjacent to the Science Building, will be open at various times. **Eating places** on the campus are the University Dining Hall and the Morris Inn.

If the **Council of the American Physical Society** meets during this convention, the Councillors will be notified by special message of the time and place of its meeting.

Post-deadline ten-minute papers, pertaining to very recent achievements of very special importance, will be considered for admission to a special supplementary programme if the abstracts are received at the office of Professor J. W. Mihelich, University of Notre Dame, Notre Dame, Indiana, not later than Friday, June 14. The abstracts will not be published. The titles of such papers as may be accepted will be written on a blackboard near the registration desk, and on this blackboard also will be announced the time and place at which these may be given.

Prospective meeting and deadlines of the Society are listed on page 275 of this Bulletin: a preliminary announcement of the Boulder meeting in September and a preliminary announcement of the St. Louis meeting in November will be found on page 274.

Make a habit of reading the instructions for the preparation of abstracts, which in this Bulletin will be found on page 275. From time to time these instructions become more stringent, for their purpose is to reduce the waste of labor and loss of time spent in editing abstracts that are badly prepared, and with the increasing size of our Bulletins these wastes and losses become steadily more serious.

Errata pertaining to abstracts in this issue will be published in a later issue of this Bulletin if received not later than Monday, July first, by Miss Ruth Bryans, American Institute of Physics, 57 East 55th Street, New York 22, New York. Write out the corrections in the form "Instead of . . . read. . . ." Add nothing. The privilege of publishing an erratum is not accorded for the purpose of enabling people to publish new data or to restore material cut out because the abstract was too long.

KARL K. DARROW, *Secretary*
American Physical Society
Columbia University
New York 27, New York

EPITOME OF THE 1957 NOTRE DAME MEETING

(Personal names are those of invited speakers, excepting "Nieuwland" which is short for Nieuwland Science Hall. DEP stands for Division of Electron Physics.)

Thursday Morning

10:30 A. Blatt, Fan, Gomer. Law.

10:00 B. Nuclear and theoretical physics I; Steffen. Nieuwland 127.

Thursday Afternoon

2:15 D. Meyer, Levi-Setti, Collins, Mullin. Engineering.

2:15 E. DEP: Good, Handler, Juenker: surface phenomena. Law.

Friday Morning

10:00 G. DEP: Morrison, Muschlitz, Watanabe; ionization phenomena. Engineering.

10:00 H. Solid-state physics I, mostly metals. Nieuwland 127.

10:00 J. General physics; Petrauskas. Nieuwland 118.

Friday Afternoon

2:00 K. Solid-state physics II, largely semiconductors. Law.

2:00 L. Nuclear and theoretical physics II. Nieuwland 127.

2:00 M. DEP: Webster: general electron physics. Engineering.

Friday Evening

7:00 Banquet of American Physical Society; speakers to be announced. University Dining Hall.

Saturday Morning

10:00 N. DEP: Lander: oxides. Engineering.

10:00 P. Laporte, Wheatley, Spence, Hebel. Law.

9:30 Q. Waldman, Browne, Mihelich. Nieuwland 127.

PROGRAMME

THURSDAY MORNING AT 10:30

Law Auditorium

(H. J. BOLGER presiding)

Invited Papers in Solid-State Physics

A1. Scattering of Charge Carriers by Impurities in Solids. F. J. BLATT, *Michigan State University.* (30 min.)

A2. Infrared Behavior of Semiconductors and Carrier-Mass Determination. H. Y. FAN, *Purdue University.* (30 min.)

A3. Field Emission from Mercury Whiskers. R. GOMER, *University of Chicago.* (30 min.)

THURSDAY MORNING AT 10:00

Nieuwland 127

(B. WALDMAN presiding)

Nuclear and Theoretical Physics I

B1. Decay of Ga^{64}.* THOMAS JACOBI, H. A. HOWE, AND WILLIAM DOUB, *University of California at Los Angeles.*—Radiations from 2.6-min. Ga^{64} have been studied with a magnetic spectrometer and gamma-ray scintillation spectrometer. Two positron groups were observed with end points of 6.09 $\pm$0.05 and 2.81$\pm$0.04 Mev and relative abundances of 62% and 38%, respectively. The corresponding log *ft* values are 6.2 and 4.8. Gamma rays of energies 0.98$\pm$0.02, 1.30$\pm$0.03, 2.25$\pm$0.04, and 3.25$\pm$0.06 Mev were also observed. The 3.25-Mev gamma ray agrees with the difference of the positron end points, while the 0.98-, 1.30-, and 2.25-Mev gamma rays agree with gamma rays found by Weller and Grosskreutz[1] in the $Cu^{63}(p,\gamma)Zn^{64}$ reaction. They did not see a gamma ray of 3.25-Mev, however. The gamma ray of 3.8-Mev reported by Cohen[2] was not observed.

* Work supported by the joint program of U. S. Atomic Energy Commission and Office of Naval Research.
[1] C. E. Weller and J. C. Grosskreutz, Phys. Rev. **102**, 1149 (1956).
[2] B. L. Cohen, Phys. Rev. **91**, 74 (1953).

B2. Low-Intensity Conversion Lines in Sm^{151} and Sn^{112}. W. T. ACHOR,* W. E. PHILLIPS, J. I. HOPKINS, AND S. K. HAYNES, *Vanderbilt University.*—The electron spectrum of Sm^{151} has been measured with a lens spectrometer and its gamma-ray spectrum with a scintillation spectrometer. These measurements yield for the 22-kev gamma transition the following values: $\alpha_L \sim 12$, $L/(M+N) \sim 1.8$, $M/N \sim 6$, which, together with energy differences and line shapes, identify the transition as *M*1. The conversion electron intensity is too feeble to be associated with the ~75-kev beta transition; this implies the existence of a ~53-kev beta transition, whose intensity is <1% of the 75-kev transition. The most reasonable assignment of spins and parities using the Mottelson-Nilsson model[1] appears to be in conflict with those predictions of the model which are based on magnetic moment measurements; this will be discussed. In a lens spectrometer study of Sn^{113}, the *K*-conversion line of the disputed 255-kev gamma transition has been found. Its intensity is ~0.3% of that of the 392-kev *K*-conversion line. Comparison of the conversion electron intensity ratio with the gamma-ray intensity ratio[2] shows that the 255-kev transition is *E*1.

* Now at Western Reserve University.
[1] B. R. Mottelson and S. G. Nilsson, Phys. Rev. **99**, 1615 (1955).
[2] G. Gardner and J. I. Hopkins, Phys. Rev. **101**, 999 (1956).

B3. Disintegration of Eu^{156}. G. T. EWAN, J. W. KNOWLES, AND D. R. MACKENZIE, *Chalk River Laboratories.*—Gamma rays and internal-conversion electrons observed in the decay of Eu^{156} have been studied using a lens β-ray spectrometer at 0.7% resolution, a curved-crystal γ-ray spectrometer, NaI scintillation spectrometer, and coincidence techniques. Eu^{156} was produced in a four-month irradiation of samarium in *NRX* by the double-neutron-capture process $Sm^{154}(n,\gamma)Sm^{155} \xrightarrow{\beta^-} Eu^{155}(N,\gamma)Eu^{156}$. Sources for study in the β-ray spectrometer were chemically separated from samarium. In the energy region, 35–300 kev, two gamma transitions assigned to Eu^{156} were observed. These have energies 89.0 and 199.2 kev, relative intensities 1 and 0.03, and are *E*2 in character, having measured *K*/*L* conversion ratios 0.88$\pm$0.05 and 2.9$\pm$0.3, respectively. In addition, high-energy gamma rays of energies 1840$\pm$20, 1940$\pm$20, 2050$\pm$20, and 2140$\pm$20 kev were observed in the scintillation spectrometer and coincidence experiments. The beta spectrum is complex having at least two components of end points 2460$\pm$20 kev and 450$\pm$50 kev. The present experiments indicate levels in Gd^{156} at 0(0+), 89 kev (2+), 298 kev (4+), 1940 kev, and 2140 kev. There is some evidence for other levels above 300 kev, but detailed study of these has not yet been possible due to the presence of Eu^{154} activity in the sources.

B4. Electron Capture of Tb^{155} to Levels in Gd^{155}.* T. J. WARD, K. P. JACOB, AND J. W. MIHELICH, *University of Notre Dame,* AND B. HARMATZ AND T. H. HANDLEY, *Oak Ridge National Laboratory.*†—A source of Tb^{155} was obtained by bombarding Dy^{156} with protons in the ORNL 86-in. cyclotron and then chemically separating by ion exchange techniques the Tb^{155} which was produced from the decay chain $Ho^{156} \rightarrow Dy^{155} \rightarrow Tb^{155}$. Tb^{155} decays by electron capture to levels in Gd^{155} with a 5.6-day half-life. The gamma ray and internal conversion spectrum from the decay of Tb^{155}, as well as that of Eu^{155}, has been examined with scintillation spectrometers and 180° permanent magnet spectrographs. The results for the Eu^{155} decay are in good agreement with those obtained by Boehm and Hatch.[1] The Tb^{155} decay populates higher lying levels in Gd^{155}. Following are the energies in kev and the multipolarities indicated by the measured conversion coefficients of the gamma-ray transitions in Gd^{155}: 18.9(*M*1 and *E*2);

26.7($E1$), 31.6($M1$ and $E2$); 45.6($E1$); 60.2($M1$ and $E2$); 86.7($E1$); 101.4; 105.6($E1$); 148.8($M1$); 160.8($M1$); 161.5 ($M1$); 163.4($M1$); 180.4($M1$); 181.6; 221.2($M1$); 239.7; 262.6($M1$); 340.8($M1$) and 368.3($E1$). Coincidence measurements have been made and levels have been established at the following energies (kev) above the ($\frac{3}{2}^-$) ground state: 60.2($\frac{5}{2}^-$); 86.7($\frac{1}{2}^+$); 105.6($\frac{3}{2}^+$); 267.1($\frac{3}{2}^+$); 368.4($\frac{1}{2}$, $\frac{3}{2}^+$) and 427.5($\frac{1}{2}$, $\frac{3}{2}^+$).

* Supported by the U. S. Atomic Energy Commission.
† Operated for the U. S. Atomic Energy Commission by the Union Carbide Nuclear Company.
[1] F. Boehm and E. N. Hatch, Bull. Am. Phys. Soc. Ser. II, 2, 231 (1957).

B5. Decay of Tm^{168} to Levels in Er^{168}. K. P. JACOB AND J. W. MIHELICH, *University of Notre Dame,** AND B. HARMATZ, *Oak Ridge National Laboratory.*†—The decay of Tm^{168} (104 day) produced by proton irradiation of Er in the ORNL 86-in. cyclotron has been studied with permanent magnet spectrographs and coincidence scintillation spectrometers. Gamma-ray transitions of 80.4, 99.9, 185, 199, 247, 448, 720±10, and 820±10 are observed. The following levels in Er^{168} have been established: 80 kev (2+), 265 kev (4+), 1080 kev, a metastable level ($T_{\frac{1}{2}}=0.12$ μsec) probably at 1280 kev, and 1800 kev. Transitions of 448 and 247 kev precede the metastable level, which may be depopulated by the transition of 199 kev.

* Supported by the U. S. Atomic Energy Commission.
† Operated for the U. S. Atomic Energy Commission by the Union Carbide Nuclear Company.

B6. Evidence for the $(p_{1/2})^2$, $(g_{9/2})^2$, and $(p_{1/2}g_{9/2})$ Configurations in Zr^{90}. RAYMOND K. SHELINE, *Institute for Theoretical Physics, Copenhagen.*—The decay of Nb^{90} results in transitions of 0.0176±0.001, 0.133±0.003, 0.142±0.002, 0.370±0.005, 0.511±0.003, 0.900±0.010, 1.137±0.006, 2.200 ±0.020, and 2.330±0.010 Mev. Relative intensities and multipolarities of most of the transitions have been determined. The anisotropy of the 0.142−1.137-Mev cascade is −0.112 ±0.046. These measurements have been used to assign the following levels (in Mev) and spins in the daughter nucleus Zr^{90}: 1.77(0+), 2.20(2+), 2.33(5−), 3.10 (probably 4+), 3.47(6+), and 3.61(8+). Following the suggestion of Ford, these levels are interpreted as proton levels arising from the ground state configuration $(p_{\frac{1}{2}})^2$ and the two excited state configurations $(g_{9/2})^2$ and $(p_{1/2}g_{9/2})$. All states expected from these configuratibns with the exception of the $(p_{1/2}g_{9/2})4-$ state are observed. The relative population of the ground state and first excited 0+ states in the beta decay of Y^{90} and the de-excitation of the 2.20(2+) state in Nb^{90} indicate that these states are highly mixed. The ground state is approximately $\frac{3}{4}(p_{\frac{1}{2}})^2$ and $\frac{1}{4}(g_{9/2})^2$ whereas the first excited state is approximately $\frac{3}{4}(g_{9/2})^2$ and $\frac{1}{4}(p_{\frac{1}{2}})^2$. Other states are relatively pure and it is possible to estimate the amount of some of the impurities by various considerations, including the failure to observe the 8+→5− transition in competition with 0.142-Mev 8+→6+ transition.

B7. Levels in Ca^{43}. O. B. NIELSEN AND R. K. SHELINE, *Institute for Theoretical Physics, Copenhagen.*—The levels in Ca^{43} have been studied by observing the decay of K^{43} and Sc^{43}. Gamma rays of 0.215±0.005, 0.376±0.004, 0.612±0.005, and 1.015±0.01 Mev in K^{43} and 0.374±0.004 Mev in Sc^{43} have been observed. Weak internal conversion lines have been studied in both Sc^{43} and K^{43}. These data, together with $\gamma-\gamma$, $\beta-\gamma$, and $\alpha^-\!-\gamma$ coincidence measurements and sum line spectra, determine decay schemes for both K^{43} and Sc^{43} and the corresponding levels and spins in Ca^{43}. The levels are in good agreement with the results of Braams.[1] A comparison will be made between the experimentally observed levels, spins, and transition probabilities and those to be expected from the intermediate coupling approach of Levinson and Ford[2] and French and Raz.[3]

[1] C. M. Braams, Phys. Rev. 105, 1023 (1957).
[2] C. Levinson and K. W. Ford, Phys. Rev. 100, 13 (1955).
[3] J. B. French and B. J. Raz, Phys. Rev. 104, 1411 (1956).

B8. Polarization Measurements on β^+ Particles Using Solid Annihilators.* LORNE A. PAGE AND FELIX E. OBENSHAIN, *University of Pittsburgh.*—In analogy to the polarization experiments in a gas, if positrons are incident on suitable solid annihilators, one can distinguish those with spins parallel to an applied field **H** from those with spins antiparallel. Essential criteria for a usable annihilator are: it should have the τ_3 component, preferably with not too long a lifetime; it should exhibit the concomitant narrow component, but preferably not too much in excess of one-third of the abundance of τ_3. In fields of 10 to 15 kilogauss singlet states of positronium (having positron spins predominantly parallel to **H**) continue to feed almost exclusively the narrow component, while a large fraction of the triplet ($m=0$) states, even in the presence of the magnetic quenching, feed the broad component. The results for fused quartz and polyethylene (the only materials run to date) are clearly consistent with the fact that Na^{22} positrons emitted with velocity **v** have $\langle \boldsymbol{\sigma}\cdot\mathbf{v}\rangle$ positive. The two-coincidence rate measured at 180° depends on the sign of H but in the opposite sense to the dependence for a gas annihilator. The motivation for the present work in solids was that they might well serve as convenient polarization detectors for examining such fundamental problems as the v dependence of positron polarization, and accordingly the work is being continued.

* Work done in the Sarah Mellon Scaife Radiation Laboratory and supported by the Office of Ordnance Research, U. S. Army.

Invited Paper

B9. Measurements of Electron Polarization in Beta Processes and the Problem of Time Reversal. R. M. STEFFEN, *Purdue University.* (30 min.)

THURSDAY AFTERNOON AT 2:15

Engineering Auditorium

(H. D. SMYTH presiding)

Invited Papers

D1. On the Scattering of Positive K Mesons by Nucleons. D. I. MEYER, *University of Michigan.*

D2. Nuclear Interactions of Neutral K Mesons. RICCARDO LEVI-SETTI, *University of Chicago.* (30 min.)

D3. Associated Production Experiments at Brookhaven. G. B. COLLINS, *Brookhaven National Laboratory.* (30 min.)

D4. Theory of the Shape of Bremsstrahlung. C. J. MULLIN, *University of Notre Dame and MURA.* (30 min.)

THURSDAY AFTERNOON AT 2:15

Law Auditorium

(E. A. COOMES presiding)

Surface Phenomena

Invited Papers of the Division of Electron Physics

E1. Transmission of Electrons through Metal Surfaces. R. H. GOOD, JR., *Iowa State College.* (30 min.)

E2. The Electrical Properties of a Clean Germanium Surface. F. HANDLER, *University of Illinois.* (30 min.)

E3. Electron Emission in Weak Accelerating Fields. D. W. JUENKER, *University of Notre Dame.* (30 min.)

Contributed Papers

E4. Photoelectric Measurements on Tantalum in Accelerating Fields.* J. L. GUMNICK AND D. W. JUENKER, *University of Notre Dame.*—The variation of photoelectric current with accelerating electric field has been investigated for tantalum. Monochromatic illumination in the near ultraviolet produces photocurrent varying with field in agreement with the Fowler expression for saturation emission[1] applied to a Schottky-type surface barrier.[2] Patch effects are observed at fields below about 10 kv/cm. For excitation energies exceeding 0.5 ev above threshold, the variation of photocurrent with the square root of applied field is approximately linear.[3] This behavior lends itself to rapid determination of threshold and has been used to follow changes in the threshold resulting from surface contamination; the values obtained compare favorably with those found by Shelton[4] for the thermionic work function of tantalum.

* Sponsored in part by the U. S. Atomic Energy Commission.
[1] R. H. Fowler, Phys. Rev. **38**, 45 (1931).
[2] E. Guth and C. J. Mullin, Phys. Rev. **59**, 867 (1941).
[3] P. E. Carroll, Phys. Rev. **104**, 660 (1956).
[4] H. Shelton, Bull. Am. Phys. Soc. Ser. II, **1**, 395 (1956).

E5. Photoelectric Measurements on Molybdenum as a Function of Angle of Incidence.* R. J. JACCODINE AND D. W. JUENKER, *University of Notre Dame.*—An investigation has been made of photoelectric current *versus* the angle of incidence of monochromatic illumination. A molybdenum ribbon was used as a photocathode in a tube of cylindrical geometry to facilitate changing the incident angle. As the angle is increased, the photoelectric yield rises to a maximum in the neighborhood of 45°, and then decreases. The ratio of maximum current to that for normal incidence is as large as four for clean polycrystalline molybdenum; this ratio decreases with surface contamination.

* Sponsored in part by the U. S. Atomic Energy Commission.

E6. Delayed Electron Emission and External Photoeffect from Ge and KCl Monocrystals after Electron and Photon Bombardment. KARLHEINZ SEEGER* AND WERNER KLEIN, *Heidelberg University* (introduced by J. Bardeen).—Using an electron multiplier for counting single electrons in high vacuum an external photoeffect in the visible spectral region was observed at −170°C with Ge after bombardment with 900-ev electrons and with KCl after uv irradiation. KCl emission peaks were observed at wavelengths of 470 and 630 mμ. A "delayed electron emission" was observed in the dark which decays with time t after bombardment according to t^{-s} and shows peaks during the warmup following bombardment. The emission is considered to arise from surface traps, the peaks being correlated to discrete trap energies. In electron bombarded Ge variation of emission with bombarding voltage has maximum value at 500 volts. Variation with bombarding time shows saturation effects, with a total number of delayed secondaries of 10^{8}/cm² and a yield 10^{-10}. The larger part of the delayed emission occurs below room temperature. After vacuum heat treatment at 700°C the emission is smaller with its major part above room temperature. The emission is considered to be more concerned with the oxide layer than the germanium itself.

* Now at University of Illinois, Urbana, Illinois.

FRIDAY MORNING AT 10:00

Engineering Auditorium

(M. H. INGHRAM presiding)

Ionization Phenomena

Invited Papers of the Division of Electron Physics

G1. Electron Impact Spectroscopy. J. D. MORRISON, *University of Chicago.* (30 min.)

G2. Formation of Negative Ions in Gases by Secondary Collision Processes. E. E. MUSCHLITZ, JR., *University of Florida.* (30 min.)

G3. Photoionization Measurements of Ionization Potentials. K. WATANABE, *University of Hawaii.* (30 min.)

Contributed Papers

G4. Electron Detachment from H^- and Li^- by Electron Impact.* SYDNEY GELTMAN, *National Bureau of Standards.*—A bound electron may be detached from a negative ion upon the impact of an electron having kinetic energy greater than the binding energy (affinity). The cross section for single electron detachment from H^- and Li^- is here calculated using

the Born approximation over the range of incident energies from threshold (0.75 ev and 0.39 ev) to about 100 ev. The ground state of these ions is $s^2\ {}^1S_0$ (He-like), which requires that the probability for detachment contain a statistically weighted average of singlet-singlet and singlet-triplet transition probabilities to continuum states. Wave functions are used which have been developed in a previous calculation[1] of the photodetachment cross section. An estimate is made of the reduction in cross section at low energies owing to the long-range Coulomb repulsion exerted on the incident electron. This detachment process should have an effect in determining the electron temperature and density and H^- concentration in stellar atmospheres.

* This work was supported in part by the Bureau of Ordnance, Department of the Navy, under NOrd 7386.
[1] S. Geltman, Phys. Rev. **104**, 346 (1956).

G5. Mobilities of Hg^+ in Helium, Neon, and Argon. LORNE M. CHANIN AND MANFRED A. BIONDI, *Westinghouse Research Laboratories.*—Studies of the mobilities of positive ions in the noble gases[1] have been extended to the case of Hg^+ in helium, neon, and argon at room temperature. The case of Hg^+ in a noble gas provides an example of a heavy ion moving in a simple gas under classical forces of interaction. For the case of Hg^+ in helium, good agreement is obtained between the present results and previous measurements made using microwave techniques.[2] The present results may also be compared by a mobility *vs* mass number plot with measurements of Tyndall's group[3] on the mobilities of alkali ions in noble gases. The present results are compared with other experimental values and theoretical values based on polarization attraction in the following table.

Gas	Present results	Microwave value	Tyndall (extrapolated)	Theory
He	19.6	19.8	19.0	15.5
Ne	5.9	···	5.9	5.13
A	1.85	···	1.9	1.79

[1] M. A. Biondi and L. M. Chanin, Phys. Rev. **94**, 910 (1954).
[2] M. A. Biondi, Phys. Rev. **90**, 730 (1953).
[3] A. M. Tyndall, *The Mobility of Positive Ions in Gases* (Cambridge University Press, New York, 1938).

G6. Similarity Principle in High-Frequency Neon Discharges. MACLIN S. HALL* AND J. G. WINANS, *University of Wisconsin.*—The similarity principle for high-frequency gas discharges states that in different discharge chambers the energy distribution of electrons will be the same at corresponding points in space if E/p, $E\Lambda$, and Λ/λ are the same.[1] E is the electric field strength, p is the gas pressure, λ is the wavelength of the hf electric field, and Λ is the characteristic diffusion length determined by the dimensions of the discharge chamber. This principle was tested by measuring breakdown and extinction electric field strengths as a function of pressure from 0.07 to 30 mm Hg for pure neon in five cylindrical Pyrex discharge tubes having different Λ. The frequencies were between 444 and 658 Mc/sec and chosen so that $\Lambda/\lambda = 9.44\times10^{-3}$. The similarity principle was found to be valid for both breakdown and extinction for the frequencies and discharge tubes used. However, it failed to predict the correct breakdown field strengths from measurements made elsewhere at 2810 Mc/sec.[2]

* Now at the National Cash Register Company.
[1] H. Margenau, Phys. Rev. **73**, 326 (1948).
[2] A. D. MacDonald and D. D. Betts, Can. J. Phys. **30**, 565 (1952).

FRIDAY MORNING AT 10:00

Nieuwland 127

(G. KUCZYNSKI presiding)

Solid-State Physics I, Mostly Metals

H1. Quenching of Imperfections in Aluminum. W. DESORBO AND D. TURNBULL, *General Electric Research Laboratory.*—Wires prepared from zone-refined aluminum when quenched from high temperatures T_i exhibit a resistivity component $\Delta\rho$, which disappears completely[1] upon isothermal holds at 273° or 300°K. Resistivity (ρ) measurements were at 20°K. For the fully-recovered wire $\rho = 4.35\times10^{-9}$ ohm-cm. For $T_i = 595$°K, $\Delta\rho$ is at least 0.60×10^{-9} ohm-cm. Following a quench from 550°C the recovery is half-completed in <50 minutes at 273°K. It is assumed that the recovery corresponds to the annealing out of point defects. Following the technique of Kauffman and Koehler,[2] we find that the activation energy E_m for the motion of the defects is 0.37 ± 0.03 ev. This compares with 0.3 ev reported by Panseri *et al.*[3] Our E_m is near the activation energy (0.4–0.5 ev) for the low-temperature clustering in Al–Cu and Al–Ag alloys.[4] From the dependence of $\Delta\rho$ on T_i it is inferred that the formation energy E_f of defects is in excess of 0.6 ev.

[1] This result is in agreement with that of M. Wintenberger [Compt. rend. **242**, 128 (1956)].
[2] J. W. Kauffman and J. S. Koehler, Phys. Rev. **97**, 555 (1955).
[3] Panseri, Gatto, and Federighi, Acta Metallurgica **5**, 50 (1957).
[4] D. Turnbull and H. Treaftis, Acta Metallurgica (to be published).

H2. Magnetic Anisotropy Constant of Nickel at Liquid Helium Temperatures. H. SATO AND A. ARROTT, *Ford Motor Company.*—The magnetic anisotropy constant of Ni depends very strongly on temperature and it is desirable to measure it down to the liquid helium temperature. Although this constant has been derived at this temperature from a ferromagnetic resonance measurement,[1] it seems that the value is too high when compared to the value expected from an extrapolation of the values obtained by static measurements at higher temperatures. For this reason we have evaluated the anisotropy by a static method at this temperature. The sample is a polycrystalline sphere 1 cm in diameter and from the magnetization curve up to 15 000 oe the anisotropy constant is estimated. Since at liquid helium temperature no increase in the saturation value by the magnetic field is expected, the accuracy of this kind of method should be considerably higher than that at higher temperatures. From the linear relation of the magnetization *vs* $1/H_i^2$ curve, we could obtain $K_1 = -7.78\times10^5$ erg/cm³. This value agrees very nicely with the extrapolated value. Actually, the contributions of K_2, etc. are not separable and the above value should be interpreted as an upper limit. But, as long as the value of K_2 is smaller than that of K_1, this contribution to the result is reasonably small.

[1] K. H. Reich, Phys. Rev. **101**, 1647 (1956).

H3. Magnetic Anisotropy of Aluminum-Iron Single Crystals.* R. C. HALL, *Westinghouse Magnetic Materials Development Laboratory* (introduced by W. J. Carr, Jr.).—The magnetic anisotropy constants of aluminum-iron single crystals in the region of 6 to 30 atomic percent aluminumwere meas -

ured by means of torque curves. Torque was obtained at infinite field strength by extrapolation of the plot of torque *versus* the reciprocal of the square root of the field strength. The anisotropy constants were evaluated from the extrapolated values of torque by a least-squares solution. Anisotropy of aluminum iron was higher than that of silicon iron in the region of 0 to 13 atomic percent. Crystals in the ordering region near Fe_3Al (about 18 to 33 atomic percent aluminum) were slowly cooled, and measurements were made for the ordered state. The anisotropy in the ordered state became zero near 22 atomic percent aluminum, was negative at higher compositions, and approached zero near 30 atomic percent aluminum. The easy direction of magnetization changed from the [100] to the [111] direction near the 22 atomic percent composition.

* Supported in part by the Wright Air Development Center.

H4. Effects of Ionic Distribution on the Temperature Dependence of Magnetocrystalline Anisotropy in Magnesium-Iron Ferrites. V. J. FOLEN AND G. T. RADO, *Naval Research Laboratory.*—The magnetocrystalline anisotropy (K_1) and saturation magnetization (M_s) of magnesium-iron ferrite monocrystals containing 0.1 to 0.5 mole percent magnetite have been measured as a function of temperature (T). Several of the low magnetite content samples were heat treated in order to alter the ionic distribution, i.e., the degree of inversion. At low temperatures, the change in the measured anisotropy produced by the change in ionic distribution was found to be large in magnitude and opposite in direction compared to that observed at room temperature.[1] For example, a change in ionic distribution corresponding to a decrease of 0.63 Bohr magneton in the absolute saturation moment resulted in an increase of 4×10^5 erg per cm^3 in $|K_1|$ at 300°K, and a decrease of 24.5×10^5 ergs per cm^3 in $|K_1|$ at 77°K. In general, the temperature dependence of the anisotropy of samples containing from 10 to 25 mole percent magnetite is more pronounced when the ionic distribution corresponds to a "high M_s state" than when it corresponds to a "low M_s state." The $K_1(T)$ curve for a sample containing 50 mole percent magnetite was found to exhibit a minimum at about 180°K.

[1] See our abstracts in Bull. Am. Phys. Soc. Ser. II, **1**, 132 (1956).

H5. Origin of the Magnetocrystalline Anisotropy in Magnesium-Iron Ferrites. G. T. RADO AND V. J. FOLEN, *Naval Research Laboratory.*—The origin of the anisotropy due to ferric ions in ferrites has been investigated by using those experimental results of the previous abstract (Folen and Rado) that pertain to Mg−Fe ferrite monocrystals in which the ferrous ion content is low. We assume that in such crystals the anistotropy (K_1) is caused by ferric ions only. Thus we can test the applicability, to ferric ions in ferrites, of an anisotropy theory[1] involving the cubic crystalline field spin Hamiltonian $(a/6)(S_x^4+S_y^4+S_z^4)$ and the molecular field approximation. To avoid "trial and error" procedures, we developed an analytical method for determining directly those three molecular field coefficients that produce the best agreement between the Néel theory and a given experimental curve of saturation magnetization (M_s) *versus* temperature (T). In our ferrite crystals these coefficients are found to be temperature independent within the experimental error. We determine the splitting parameters a_A and a_B corresponding to the A and B sites by using the experimental curves of, for example, $K_1(T)$ and $M_s(T)$ belonging to one inversion state of one crystal. Preliminary results are: $a_A\approx-0.0092$ cm^{-1} and $a_B\approx+0.023$ cm^{-1}, in reasonable agreement with published paramagnetic resonance results.

[1] K. Yosida and M. Tachiki, Progr. Theoret. Phys. (to be published).

H6. Effect of Impulsive Loads on the Structure of Cobalt. E. W. LAROCCA AND L. A. BURKARDT, *U. S. Naval Ordnance Test Station* (introduced by G. J. Plain).—Samples of 99.99% cobalt were subjected to pressures on the order of 10^6 psi, with extremely high loading rates, by means of an explosively activated press. The cobalt was quenched from 700°C to retain the beta phase before explosive loading. X-ray diffraction patterns showed that the prior (face-centered cubic) structure was partially converted to the more stable alpha (hexagonal) phase after the application of an explosive load. While the transition of a metastable phase to a more stable phase in cobalt by cold-working is a fairly well-known phenomenon, it is believed that these experiments are the first showing that the transition can occur in extremely short times.

H7. Torsional Strain of Whiskers. PAUL J. SHLICHTA.—The x-ray diffraction of chalcotrichite, a filamentary mineral form of cuprous oxide, has been studied utilizing Laue, rotation, and Weissenberg techniques. The Laue pattern contains strain elongated reflections which give it spiral symmetry: i.e., p^3 invariant to rotation of the sample about its axis. This torsional strain indicates that chalcotrichite is the whisker form of ordinary cuprite. The rotation technique introduces an additional symmetry element giving an elongated reflection pattern of *mm* symmetry. Weissenberg reflections show even greater elongation, similar to the streaks reported by Treuting[1] for tin whiskers. Laue reflections of iron and copper whiskers are slightly elongated and complex in structure, but the resultant pattern has apparent *mm* rather than spiral symmetry. Rotation and Weissenberg patterns show little or no elongation. A copper "spiral," similar to those reported by Brenner,[2] gives a single crystal Laue pattern indistinguishable from those of ordinary copper whiskers.

[1] R. G. Treuting, Bull. Am. Phys. Soc. Ser. II, **1**, 333 (1956).
[2] S. S. Brenner, Acta Metallurgica **4**, 62 (1956).

H8. Electron Optical Investigations of Glasses. P. J. BRYANT AND A. H. WEBER, *Saint Louis University.*—The macroscopic surface structure of glass was investigated by means of optical photomicrographs. The surfaces were photographed (1) in their original form, (2) after a hydrofluoric acid etch, (3) after areas immediately below the original surface were exposed by a fracturing technique, and (4) after the deposition of thin Bi films (5–20 A). The Bi material apparently accentuates devitrified areas of glass by forming epitaxial type deposits. Additional evidence of devitrification was obtained from photographs of untreated surfaces and by an electron diffraction study. The atomic structure of various glasses was investigated by electron diffraction utilizing a modified rotating sector technique.[1] This technique provides an accurate semiempirical estimation of the amount of coherent scattering. Several independent experimental methods were devised as further checks on the correction. A sample of high-purity Corning Silica was analyzed by this electron diffraction method and the results were compared with those obtained by neutron diffraction[2] from the same sample.

[1] P. P. Debye, Physik. Z. **40**, 66 (1939).
[2] Breen, Delaney, Persiani, and Weber, Phys. Rev. **105**, 517–521 (1956).

H9. Some Applications of Relativistic One-Body Equations to Solid-State Physics. W. A. BARKER, *St. Louis University.*—There are many problems in solid-state physics which involve electron spin and nuclear spin. Spin is a relativistic concept. It is best described by a relativistic wave equation. The Dirac equation includes both spin effects and high-velocity effects. The approximately relativistic waves equation which one can easily obtain from the Dirac equation by a Foldy-Wouthuysen transformation[1] includes spin effects but neglects ultra-relativistic effects. Hence, it provides a useful and suggestive way of obtaining interactions involving electronic and nuclear spins in solid-state problems. Several examples will be discussed.

[1] L. L. Foldy and S. A. Wouthuysen, Phys. Rev. **78**, 29 (1950).

FRIDAY MORNING AT 10:00

Nieuwland 118

(O. LAPORTE presiding)

General Physics

J1. Quadrupole Coupling in the Alkali Polyhalides. C. D. CORNWELL AND R. S. YAMASAKI, *University of Wisconsin.*—Nuclear quadrupole transitions have been observed for these alkali polyhalides: $CsCl_2I$, $KCl_2I \cdot H_2O$, KCl_3I, $CsCl_4I$, $RbCl_4I$, $KCl_4I \cdot H_2O$, KCl_4I, $NaCl_4I \cdot 2H_2O$. Comparison of the resonance frequencies shows that variations due to crystal effects in these substances amount in most cases to less than a megacycle. The average chlorine resonance frequencies in the dichloroiodides and tetrachloroiodides, 19.2 and 22.3 mc, respectively, at room temperature, can thus be considered to be representative of unperturbed ICl_2^- and ICl_4^- groups. These values suggest a bonding scheme in which the electron distribution is shifted outward toward the chlorine atoms to such an extent that *d* orbitals do not appear to be required for the description of the valence state of the central iodine atom. Quadrupole coupling data for halide atoms in several other substances can be interpreted in a similar fashion. Marked crystal perturbations are observed for $KICl_4 \cdot H_2O$ and the nature of these effects will be described.

J2. Charge Distributions on Freshly Separated Glass-Polyester Interfaces.* N. M. TRIVISONNO AND SELBY M. SKINNER, *Case Institute of Technology.*—The characteristic charge patterns over the surfaces of freshly separated glass-polyester adhesion samples (prepared so as to yield nearly identical oscilloscope traces on break)[1] have been studied by spraying them with a mixture of oppositely charged fluorescent powders. The distribution pattern is sharper on the polyester, with indication of diffusion of pattern over the surface of the glass. When the separation of circular cylindrical samples is performed in air, the pattern consists of an outer positive ring on the polymer, and from one to three inner rings of alternating charge; with samples of square cross section, similar results are obtained, the patterns being similarly smoothly curved. In the centers of the inner rings, a series of charge lines radiate out towards the edge of the sample. Attempts to modify the pattern drastically by methods of sample preparation, or of breaking apart, produced only small variations in pattern. The presence of vapor bubbles or included air in the polyester created separate patterns superimposed on the over-all one. Flaws at the adhesive interface also caused distortions in the pattern. Charge patterns on opposite surfaces are mirror images.

* With the partial support of the Office of Ordnance Research, U. S. Army.
[1] Skinner, Kern, Park, and Trivisonno, Bull. Am. Phys. Soc. Ser. II, 2, 98 (1957).

J3. Dielectric Properties of Some Polyesters.* D. J. SCHEIBER† AND D. J. MEAD, *University of Notre Dame.*—The real and imaginary parts of the dielectric constant of certain polyesters, chiefly polymethyl methacrylate, have been measured in the temperature range from +65°C to −190°C and at frequencies between 100 cps and 200 kc. Polymethyl methacrylate showed a strong dielectric loss peak at the upper end of the temperature range. Samples exposed to water vapor showed a smaller dielectric absorption peak at low temperatures which can be made to disappear by drying the sample. This low-temperature peak, due to the absorbed water, may be responsible for certain reports in the literature indicating a low-temperature absorption process in polymethyl methacrylate. Similar studies were made on polymethyl acrylate, polyethyl methacrylate, and polyethyl acrylate.

* Supported in part by the Office of Naval Research.
† United States Rubber Company Fellow.

J4. Simultaneous Detonation of High Explosive along a Line.* J. O. ERKMAN AND ADRIANO GARSIA, *Stanford Research Institute.*—Detonation of a thin layer of explosive at a point, using a conventional cap and booster charge, results in a detonation front lying approximately in an arc of an expanding circle in the plane of the explosive. The induced supersonic flow in a plate of metal or other material in contact with the explosive will be three-dimensional because of curvature of the detonation front, and the attenuation of the shock induced in the medium. If the material is transparent, flow must be observed through the curved interface separating the shocked and undisturbed material, and distortion results. Moreover, this flow is difficult to analyze. These difficulties are minimized if curvature of the detonation front is eliminated. This is accomplished by warping the high-explosive layer between the detonation and the region of observation into a particular geodesic surface. In traversing this warped region, the detonation is transformed into a front lying in a straight line, advancing perpendicularly to itself. Except for edge effects, induced flow becomes two-dimensional, hence easier to observe and analyze. High-speed photographs showing the progress of a detonation front over such a surface will be shown.

* Work performed for U. S. Army Ordnance Division.

J5. Sound Absorption in Liquid Helium. K. DRANSFELD* AND J. WILKS† (introduced by B. Bleaney).—Measurements[1] on the absorption of sound at 14.4 Mc/sec have been extended to include measurements under the vapor pressure at a frequency of 6 Mc/sec. The maximum attenuation at 6 Mc/sec has a greater value, and occurs at a lower temperature than at 14.4 Mc/sec. This behavior is in agreement with the theory of Khalatnikov[2] as evaluated by Archipov.[3] As at 14.4 Mc/sec the absorption at the lower temperatures is much greater than can be accounted for by the theory of second viscosity; it appears that in this region it may not be possible to ignore the coefficient of irreversible heat transfer (Khalatnikov, 1952).[4]

* Now at Bell Telephone Laboratories.
† At the Clarendon Laboratory, Oxford.
[1] Newell and Wilks, Phil. Mag. 1, 588 (1956).
[2] Khalatnikov, J. Exptl. Theoret. Phys. (U.S.S.R.) 20, 243 (1950).
[3] Archipov, Doklady Akad. Nauk S.S.S.R. 98, 747 (1954).
[4] Khalatnikov, J. Exptl. Theoret. Phys. (U.S.S.R.) 23, 21 (1952).

J6. Ultrasonic Attenuation in Several Liquids.* J. H. CHEN, R. L. ANTHONY, AND A. A. PETRAUSKAS, *University of Notre Dame.*—Ultrasonic absorption peaks were observed in 2 methylbutane, in 2, 3 dimethylbutane, and in 3 methylpentane.[1] The mechanism of absorption can be explained in terms of a hindered rotation about the middle C−C bond in butanes and about the second and third C−C bond in pentanes, if one assumes unequal values of potential minima for the different rotational isomeric states. The energy differences between the potential minima were found to be about 0.9 kcal/mole in 2 methylbutane and 2, 3 dimethylbutane and about 0.95 kcal/mole in 3 methylpentane. Attenuation peaks were observed in 2 methylpentane and in 1, 2 dibromoethane

in the range of 1 Mc to 35 Mc. The activation energy of 2 methylpentane was found to be about 4.4 kcal/mole and the activation energy of 1, 2 dibromoethane was found to be about 16 kcal/mole. No ultrasonic attenuation peaks were observed in pure 1, 2 dichloroethane in the range of 1 Mc to 35 Mc and from −33°C to 83°C. Attenuation peaks appeared upon dilution of 1, 2 dichloroethane with carbon tetrachloride. The activation energy was found to be about 18 kcal/mole.

* Supported in part by the Office of Naval Research.
[1] J. M. Young and A. A. Petrauskas, J. Chem. Phys. **25**, 943 (1956).

Invited Paper

J7. Studies of Rotational Isomers in Liquids by Use of Ultrasonics. A. PETRAUSKAS, *University of Notre Dame.* (30 min.)

FRIDAY AFTERNOON AT 2:00

Law Auditorium

(F. J. BLATT presiding)

Solid-State Physics II, Largely Semiconductors

K1. Detection of Dislocation Arrays in Deformed Silicon by Etching. W. C. DASH, *General Electric Research Laboratory.*—A new method of delineation of dislocations in silicon supplementary to decoration techniques[1] has been developed. It is of particular interest in studying zone-floating silicon which frequently has too many dislocations for convenient study by decoration. Slices parallel to glide planes of the specimen are chemically polished and then "slow-etched" for about 15 minutes to an hour, as described in the reference. Pits are formed where dislocations intersect the surface at large angles and sharply defined channels are formed where they lie nearly parallel to the surface. The arrays in plastically deformed material are very similar in form to those seen by decoration techniques. Frank-Read sources are found in large numbers and apparently are mainly responsible for the deformation. "Streamers" extending from cusps on moved dislocations are possible evidence of motion of jogs. A photograph of similar streamers seen by the decoration method will be shown. The etching method has the advantage that dislocations in very pure silicon can be studied without heat treatment following deformation.

[1] W. C. Dash, J. Appl. Phys. **27**, 1193 (1956); Report of the Lake Placid Conference on Dislocations (1956) (to be published).

K2. Observation of Dislocation Arrays in Germanium. W. W. TYLER AND W. C. DASH, *General Electric Research Laboratory.*—Dislocation arrays in deformed germanium have been observed using the following technique. Single crystal bars are deformed by twisting about a ⟨111⟩ axis at temperatures between 550°C and 650°C. Lithium is diffused into the crystals at temperatures between 400°C and 650°C and then precipitated at room temperature. The Li precipitates may be observed optically after selective etching of polished Ge surfaces. Whereas in undeformed samples the precipitates are randomly spaced, in regions of heavy deformation most of the precipitates appear on (or near) dislocations. Dislocation arrays observed near (111) surfaces by this technique are similar to those previously observed in silicon by transmission studies[1] and by surface etching techniques (see previous abstract). Precipitate patterns in samples which were not heated above 550°C indicate the presence of simple dislocation arrays having crystallographic orientation associated with either internal Frank-Read sources or surface sources. In samples either deformed or Li-diffused at >600°C the dislocation patterns are complex suggesting the motion of dislocations subsequent to deformation.

[1] W. C. Dash, J. Appl. Phys. **27**, 1193 (1956).

K3. Hartree-Fock Atomic Wave Functions for Neutral Ge. W. W. PIPER, *General Electric Research Laboratory.*—Self-consistent Hartree-Fock wave functions have been obtained for the ground state (^3P) of neutral Ge. Recently completed functions for Ge^{+4} were used as starting functions for the inner shells.[1] Analytic orbitals calculated by Nesbet[2] provided initial $4s$ and $4p$ wave functions. The $2s$ and $2p$ wave functions were not significantly altered. The $3s$ and $3p$ wave functions did not change by more than 0.002 while the $3d$ wave function varied by as much as 0.01. The final one-electron eigenvalues obtained for the $4s$ and $4p$ shells are 1.103 and 0.575 rydbergs, respectively. Comparing these results to the corresponding Hartree functions,[3] the outer shells are more compact when exchange is included, as one would expect. The radius of a sphere containing half the charge in the $4s$ shell is 2.17 au without exchange and 2.11 au with exchange. The $4p$ shell shrinks more markedly with the half-radius decreasing from 3.20 to 2.68 au.

[1] W. W. Piper, Bull. Am. Phys. Soc. Ser. II, **2**, 132 (1957).
[2] R. K. Nesbet (private communication).
[3] Hartree, Hartree, and Manning, Phys. Rev. **59**, 306 (1941).

K4. Multiple Donor Impurities in Germanium. J. A. ARMSTRONG, W. W. TYLER, AND H. H. WOODBURY, *General Electric Research Laboratory.*—The acceptor action of impurities in germanium has been correlated with electron configurations. For example, gallium ($4s^24p$) is a single acceptor; zinc ($4s^2$) is a double acceptor; and copper ($4s^1$) is a triple acceptor. This tendency to complete a tetrahedral bonding arrangement is consistent with the donor action of arsenic ($4s^24p^3$) and suggests that selenium ($4s^24p^4$) and tellurium ($5s^25p^4$) might act as double-donor impurities. Preliminary studies indicate that both Se and Te show multiple donor action. Te-doped crystals, for which the results are more conclusive, indicate the presence of donor levels in about equal concentrations at 0.10 ev and 0.28 ev from the conduction band. There is also evidence for a donor level at about 0.13 ev from the valence band in Te-doped samples made p-type by compensation with Ga. Because of the low solubility of Te in Ge ($k_0 \sim 10^{-6}$) and problems associated with loss of Te vapor from the Ge melt during growth, it has not been established that this third level is present in the same concentration as the upper levels. Photoconductive decay measurements at low temperatures in p-type samples containing Te show pronounced electron trapping which is probably associated with multiply charged positive impurity sites.

K5. Optical Phonon Contribution to Carrier Energy Losses in Semiconductors.* THOMAS N. MORGAN, *University of*

Illinois.—Measurements of deviations from Ohm's law in semiconductors in high electric fields give information about energy loss processes for energetic electrons and holes. We have used microwave fields to heat the carriers and have observed the resulting changes in dc resistance in germanium and silicon specimens at temperatures between 77°K and 300°K. The results are in disagreement with the theory of Shockley[1] and others based on the interaction of electrons with acoustical phonons. A theory which includes intervalley and optical phonon scattering gives good agreement with the experimental results and allows a determination of the phonon energies involved and the coupling strengths of the interactions which control the energy loss. These high-energy phonon processes dominate the energy transfer of carriers in germanium and silicon down to temperatures below liquid nitrogen.

* Supported by the U. S. Air Force Office of Scientific Research and Signal Corps.
[1] W. Shockley, Bell System Tech. J. **30**, 990 (1951).

K6. Dependence of Lifetime and Mobility on Acceptor Concentration in P-Type InSb at 300°K.* A. E. Attard and R. N. Zitter, *Chicago Midway Laboratories.*—Measurements of PEM and Hall effects and of magnetoresistance have been made on a number of uncompensated *P*-type InSb samples at 300°K. The general behavior of the observed effects were in agreement with the relations derived in a previous report,[1] so that consistent values of carrier lifetimes and electron and hole mobilities were obtained. Acceptor concentrations of the samples used range from 10^{15} to 10^{18} cm^{-3} (as determined at 77°K). It is found that μ_e varies as $N_a^{-\alpha}$ and μ_h varies as $N_a^{-\beta}$, with $\alpha \simeq \frac{1}{2}$ and $\beta \simeq \frac{1}{2}$. From theoretical considerations,[2] it is expected that direct radiative recombination lifetimes will *not* be observed in nondegenerate InSb. The result of the present measurements is that the small values of carrier lifetime ($\leq 5\times10^{-9}$ sec) and the dependence of lifetime on acceptor concentration in the range $10^{15}-10^{17}$ cm^{-3} indicate that recombination takes place by a process other than direct radiative recombination. The effects of compensation will be discussed and comparison with lifetime measurements recently made elsewhere will be evaluated.[3,4]

* This research was supported by the U. S. Air Force, through the Office of Scientific Research of the Air Research and Development Command.
[1] S. W. Kurnick and R. N. Zitter, J. Appl. Phys. **27**, 278 (1956).
[2] W. P. Dumke, Phys. Rev. **105**, 139 (1957).
[3] G. K. Wertheim, Phys. Rev. **104**, 662 (1956).
[4] D. G. Avery and D. P. Jenkins, J. Electronics **1**, 145 (1955).

K7. Oscillatory Magnetoresistance in InSb. Arnold H. Kahn, *National Bureau of Standards.*—The de Haas-van Alphen type oscillatory behavior of the low-temperature longitudinal magnetoresistance of *n*-type InSb[1] is analyzed according to the Landau[2] theory of the free electron gas in a magnetic field. Relaxation times are computed for ionized impurity scattering of electrons, within and between Landau levels. The Boltzmann equation is solved for degenerate statistics and the conductivity in high magnetic field then obtained. Oscillatory behavior in good agreement with experiment is predicted. The oscillations arise as a direct consequence of a vanishingly small relaxation time for electrons in the highest occupied Landau level when the Fermi level is close to the bottom of that level.

[1] H. P. R. Frederikse and W. R. Hosler, Can. J. Phys. **34**, 1377 (1956).
[2] L. D. Landau, Z. Physik **64**, 629 (1930).

K8. Light-Induced Plasticity in Semiconductors. G. C. Kuczynski and R. F. Hochman, *University of Notre Dame.*—It has been found that light of wavelength between 4.0 and 2.0 μ, or shorter than 0.4 μ, decreases the hardness of the surface layer on *n*-type germanium and silicon by 10 to 40%. This softening effect extends to a depth of about 10^{-4} cm and seems to be directly proportional to the light intensity. It is also sensitive to surface preparation.

K9. Tensile Properties of Some Graphites at 2200 to 2750°C. H. E. Martens, L. D. Jaffe, and J. O. Jepson, *California Institute of Technology.*—The tensile properties of six grades of graphite were determined at 2200–2750°C. The specimens had a gauge section $\frac{1}{4}$-inch diameter by 2 inches long and were heated in helium by an external graphite heater. At 2500°C and above, where the material exhibited some plasticity, load-deformation curves were recorded. A peak in the strength-temperature curve at approximately 2500°C was found. Tensile strengths here were approximately double those at room temperature. With strain rates of 2.5×10^{-6} to 20×10^{-6} per second, all grades failed brittlely at 2200°C with elongations of less than 1%. At 2500°C, elongations up to 5% were obtained; and at 2750°C, up to 20%. The reduction in area was always less than 5%. Elongations greater than 5% therefore caused decreases in density. Decreases in density up to 15% were found. These were proportional to the elongation. In both an extruded and a molded grade, the strength was greater and the elongation smaller when measured parallel to the grain.

K10. Optical Absorption of Lithium Iodide. E. A. Taft and H. R. Philipp, *General Electric Research Laboratory.*—The results of intrinsic photoelectric emission measurements on the alkali iodides have allowed an edge-like structure appearing in optical absorption data to be associated tentatively with band-to-band transitions in these salts.[1] For RbI and KI, this absorption edge is very pronounced. It moves closer to the exciton absorption peak for NaI and becomes less distinct. For LiI, it appears to have moved under the exciton peak, which becomes weaker, and resembles the absorption in AgCl and AgBr.[2] These data are discussed and qualitatively related to lattice constants of these halides.

[1] W. Martienssen (to be published in J. Phys. Chem. Solids) has made an extensive investigation of the optical absorption of the alkali iodides. Our data, although not as detailed, corroborate his findings.
[2] S. Tutihasi, Phys. Rev. **105**, 882 (1957). W. Martienssen has kindly furnished us data of Y. Okamoto (to be published) in agreement with those of Tutihasi.

K11. Approximate Wave Functions for the *M* Center.* Barry S. Gourary and Perry J. Luke, *Applied Physics Laboratory, The Johns Hopkins University.*—We have obtained approximate wave functions for Seitz's model[1] of the *M* center in alkali halides with the NaCl structure. The method is an adaptation of the techniques of Gourary and Adrian[2] to the *M* center. Several transitions are obtained, one of them corresponding to the *M* band. Oscillator strengths have been computed. The hyperfine interactions have also been esti-estimated.

* Work supported by the Bureau of Ordnance, Department of the Navy.
[1] F. Seitz, Revs. Modern Phys. **26**, 7 (1954).
[2] B. S. Gourary and F. J. Adrian, Phys. Rev. **105**, 1180 (1957).

K12. Some Optical Properties of Single Crystals of Hexagonal Zinc Sulfide. D. T. F. Marple, P. D. Johnson, and W. W. Piper, *General Electric Research Laboratory.*—The fundamental optical absorption edge in hexagonal zinc sulfide has been studied as a function of pressure and temperature with radiation polarized both parallel to and perpendicular to the crystallographic *c* axis (extraordinary and ordinary rays, respectively). The crystals used were plates one to five microns thick. An absorption coefficient of 5×10^{3} cm^{-1} occurs at 3300 A (3.75 ev) for the extraordinary ray and at 3330 A (3.72 ev) for the ordinary ray and for a temperature of 20°C. The temperature coefficient from room temperature to 120°C is the same in the two directions and amounts to -7×10^{-4} ev/C°. For the same absorption coefficient and at room temperature the pressure coefficient is independent of the plane of polarization, is linear up to 1700 atmospheres, and amounts to 8×10^{-6} ev/atmosphere. Intereferences were observed in the polarized radiation transmitted through the crystals at

wavelengths from the near infrared to the absorption edge. The optical dispersions for the parallel and perpendicular directions of polarization were deduced from these data, and they agree closely with the dispersion of cubic zinc sulfide.[1]

[1] J. R. DeVore, J. Opt. Soc. Am. **41**, 416 (1951).

K13. Nuclear Magnetic Resonance in Pile-Irradiated KBr.* JOHN F. HON AND P. J. BRAY, *Brown University*.—Using a Pound-Watkins type recording spectrometer some preliminary observations have been made of the Br^{81} line in a KBr crystal irradiated in the warer-cooled facility of Brookhaven. The sample was irradiated with a total integrated flux of 6×10^{18} nvt. The intensity of the line in the irradiated sample has been compared with that of a similar sample, not irradiated, at magnetic fields of 5000 and 7500 gauss. The sample has been maintained at room temperature since removal from the pile. Two months after removal from the pile the intensity of the line in the irradiated sample was about 70% of the intensity in the control sample. Three months after removal from the pile the intensity had increased to about 85% of that of the control sample. These results were independent of field. A crude calculation has indicated that the density of defects (observable by this means) introduced by the irradiation was about 10^{-4} defect/atom two months after the sample was removed from the pile.

* This work supported by the U. S. Atomic Energy Commission.

FRIDAY AFTERNOON AT 2:00

Nieuwland 127

(G. R. COLLINS presiding)

Nuclear and Theoretical Physics II

L1. $Be^9(d,p)Be^{10}$ and $Be^9(d,t)Be^9$ Angular Distributions at 225 kev. J. E. HYDER,* G. L. HARMON, AND C. D. CURTIS, *Vanderbilt University*.—A CsI(Tl) detector at a fixed angle monitored protons and tritons from a 50 μ g/cm^2 beryllium target while a similar detector mounted in a rotatable section of the reaction chamber measured the pulse-height spectrum of charged particles at angles continuously variable from 0° to 140°. The angular distributions of the ground-state protons and triton groups were determined at a deuteron bombarding energy of 250 kev. The proton distribution shows pronounced backward peaking with a shape in agreement with that of others[1,2] at approximately 300 kev. The triton distribution shows a minimum in the backward direction with peaking forward at small angles and a second maximum near 80°. This differs from the work at 150 kev[1] and 300 kev[1,2] and presents a shape somewhat like that at 600 kev.[1,2] Continuing work will give the triton distribution at the present and other energies with some improvement due to better separation from a nearby alpha peak. Total yields of the proton and triton groups are approximately equal.

* U. S. Atomic Energy Commission Radiological Physics Fellow.
[1] De Jong, Endt, and Simons, Physica **18**, 676 (1952).
[2] I. Resnick and S. S. Hanna, Phys. Rev. **82**, 463 (1951).

L2. Coulomb Excitation of the Second 2^+ State in Even-Even Medium Weight Nuclei. P. H. STELSON AND F. K. MCGOWAN, *Oak Ridge National Laboratory*.—The location of the second 2^+ state has been established for nine even-even medium weight nuclei by means of Coulomb excitation produced by 8-, 9-, and 10-Mev α particles. The relatively weak excitation of these states is detected by a coincidence measurement of the cascade gamma rays. The locations of the second 2^+ state are (in kev): Ru^{104}, 893±7; Ru^{102}, 1100±9; Ru^{100}, 1355±16; Pd^{110}, 812±7; Pd^{108}, 941±7; Pd^{106}, 1120±8; Cd^{116}, 1217±11; Cd^{114}, 1200±10; and Cd^{112}, 1295±16. In addition, the $B(E2)$ for excitation of these states have been determined. The second 2^+ state in Pd^{106} is very close to the well-known 0^+ state at 1137 kev. This is in agreement with the "near harmonic" model which predicts a close-lying triplet of 0^+, 2^+, and 4^+ states at about twice the excitation of the first 2^+ state. The location of the second 2^+ state in Cd^{114} agrees with the work of Motz.[1] For Cd^{114} we find the $B(E2)$ for decay are $(1.6\pm0.3)\times10^{-48}$ and $(2.0\pm0.4)\times10^{-48}$ e^2 cm^4 for the cascade and crossover transitions, respectively. These are 47 and 0.6 times the independent particle estimate (taking $R=1.2\times10^{-13}$ A$^{1/3}$ cm).

[1] H. T. Motz, Phys. Rev. **104**, 1353 (1956).

L3. Use of Li^6I(Eu) as a Scintillation Detector and Spectrometer for Fast Neutrons. R. B. MURRAY, *Oak Ridge National Laboratory*.—A previous paper[1] reported a substantial improvement in the scintillation response of Li^6I(Eu) crystals to monoenergetic fast neutrons upon cooling the crystals to −138°C. Further experiments have been carried out with a cooling apparatus in which the crystal is maintained at −196°C. The pulse-height spectra from monoenergetic neutrons at 2.9 and 14.4 Mev demonstrate well-defined peaks with a full width at half-maximum at 14% and 6%, respectively. The spectrum from $Be^9(d,n)B^{10}$ neutrons (with $E_d=550$ kev) shows five neutron groups between 1 and 5 Mev, corresponding to the first five levels of B^{10}. The measured neutron spectrum of a Po-Be source is in accord with measurements made elsewhere by proton recoil techniques. A plot of pulse height *versus* neutron energy between 0 and 14 Mev demonstrates a slight curvature at higher energies. The principal features of Li^6I(Eu) as a fast-neutron spectrometer are a relatively high detection efficiency (~0.1%), and moderate resolution. The gamma contribution to an observed pulse-height spectrum can be monitored with an auxiliary Li^7I(Eu) crystal.

[1] R. B. Murray and J. Schenck, Bull. Am. Phys. Soc. Ser. II, **1**, 296 (1956).

L4. Total Neutron Cross Sections near 14.1 Mev.* JERRY P. CONNER, *Los Alamos Scientific Laboratory*.—The total cross sections of C, Ca, Ti, Ba, La, Ce, Nd, Sm, Gd, Er, Ta, Au, and Pb for neutrons of energies between 13.1 and 15.6 Mev have been measured by the transmission technique with good geometry. The neutron source was the $T(d,n)He^4$ reaction with the Los Alamos Cockcroft-Walton accelerator and thin tritium-in-metal targets. The neutron energy spread was achieved by observing neutrons at various angles, from 0° to 145°, to the accelerated deuteron beam and by using different accelerating energies up to 450 kv. Scattering samples had a transmission of from 50 to 70%. The geometry was such that a scattering in the sample of more than about 2° removed the neutron from the beam to the stilbene scintillation detector. The total cross section of carbon for neutrons was found to

vary from 1.41×10^{-24} cm² at 13.1 Mev to a minimum of 1.31×10^{-24} cm² at 14.2 Mev to 1.49×10^{-24} cm² at 15.6 Mev. Other elements showed smaller cross-section variation with energy.

* Work performed under the auspices of the U. S. Atomic Energy Commission.

L5. Transitions in Sm^{150} Excited by Resonant Neutron Capture.* LAWRENCE ROSLER AND CHARLES A. FENSTERMACHER,† *Yale University.*—Gamma rays from Sm^{150} following neutron capture in several resonances in Sm^{149} have been studied in the energy range 0.1 to 1.5 Mev, using a NaI scintillation spectrometer in conjunction with the Yale slow neutron velocity selector. Transitions of energy 342 ± 5, 448 ± 5, 588 ± 6, 697 ± 11, 741 ± 8, 873 ± 12, and 1194 ± 18 kev were observed. All these energies are in satisfactory agreement with those previously reported.[1] Absolute intensities of the prominent low-energy transitions have been measured for the resonances at 0.096, 0.86, and 4.9 ev. Angular correlation measurements on the 342- and 448-kev transitions indicate that the second excited level is a 3+ level. Results of other coincidence measurements will be presented and modifications to the published level scheme[1] proposed.

* Research supported by the U. S. Atomic Energy Commission.
† du Pont Predoctoral Fellow.
[1] Ad'yasevich, Groshev, and Demidov, *Proceedings of the Moscow Meeting on the Peaceful Uses of Atomic Energy* (July, 1955).

L6. Activation Cross Sections for "25-kev" Sb–Be Neutrons.* REX BOOTH, W. P. BALL, AND MALCOLM H. MACGREGOR, *University of California, Livermore.*—"25-kev" Sb-Be photoneutron activation (n,γ) cross sections relative to those of iodine[1] and gold[2] have been measured for various elements ranging from sodium to bismuth. In some cases foils and in other cases two-component samples containing an unknown and a standard in the form of salts, physical mixtures, or elements containing isotopic mixtures, were irradiated in both a photoneutron beam and a thermal neutron beam. The thermal neutron exposure, together with known thermal cross sections of the components, served to calibrate the counting efficiency of the system. The activity of each component was both beta and gamma counted. Half-lives were used for isotopic identification. Internal cross checks reduced systematic errors. Some results in millibarns are: Na^{23} 1.0 ± 0.2; K^{41} 19 ± 3; Ni^{64} 8 ± 2; Cu^{63} 111 ± 13; Cu^{65} 48 ± 9; As^{75} 590 ± 90; Y^{89} 25 ± 5; Pd^{105} 550 ± 150; In^{115} 800 ± 120; Ta^{181} 1280 ± 150; W^{186} 260 ± 40; Bi^{209} 1.4 ± 0.60. Others will be presented. Agreement with Lazar *et al.*[3] is satisfactory.

* This work was performed under the auspices of the U. S. Atomic Energy Commission.
[1] R. L. Macklin, Bull. Am. Phys. Soc. Ser. II, 1, 264 (1956).
[2] Lazar, Lyon, and Macklin, Bull. Am. Phys. Soc. Ser. II, 2, 15 (1957), and private communication.

L7. Speculation on the Cause of the Cosmic-Ray Shower Second Maximum.* S. P. SHEN, *State University of New York College for Teachers at Albany.*—Analysis of data obtained to date by various workers suggests the following: (a) The controversial second Rossi maximum most probably represents nuclear events (stars) generated in the air (see Bothe and Kraemer) below the absorber by neutrons; (b) there are indications that, *occasionally*, these nuclear events simply *do not exist*, and the second maximum consequently cannot be detected. (Even when the events do exist, their successful detection still requires a favorable counter geometry.) The occasional disappearance, if real, of these events is understandable only in terms of a time-variation in some component (neutrons?) of the sea-level radiation. Such a variation cannot be flare-associated and would require a long and slightly irregular period not unlike that of the Forbush-Neher[1] variation. The above conclusions can reconcile the apparently contradictory data hitherto obtained. Test experiments are suggested. The presence[2] of a faint "second maximum" in Soberman's 1952–1954 neutron *vs* altitude curves may be attributable to a similar mechanism.

* Supported in part by the Research Corporation.
[1] H. V. Neher, Phys. Rev. **103**, 228 (1956).
[2] S. A. Korff (private communication). See R. K. Soberman, Phys. Rev. **102**, 1399 (1956); N. Y. Univ. Tech. Rept. (July 1, 1955).

L8. Energy Loss of 1.75-Mev Electrons.* W. C. MILLER AND D. F. DEMPSEY,† *University of Notre Dame.*—We have measured the energy loss of a monoergic beam of 1.75-Mev electrons obtained from an electrostatic generator. The momentum distribution after passing through a foil was measured with a magnetic spectrometer. The foils used were aluminum, copper, and gold, each of four thicknesses of about 63, 126, 189, and 252 mg/cm². The most probable energy losses were in good agreement with the Landau theory.

* Assisted by the joint program of the Office of Naval Research and the U. S. Atomic Energy Commission.
† Now at Canisius College, Buffalo, New York.

L9. Correction to the Lamb Shift Due to Proton Charge Distribution.* EDWARD M. MACKINNON, *St. Louis University* (introduced by Z. V. Chraplyvy).—Recent high-energy scattering experiments of electrons from protons in polyethylene indicate that the charge distribution of the proton can be represented by

$$4\pi\rho(r)=\frac{200}{3a_H{}^4}r\exp\left[\frac{\sqrt{20}}{a_H}r\right],\quad a_H=(0.78\pm0.05)f.^1$$

The matrix element proper to the Lamb shift was recalculated using this charge distribution and suitably modified relativistic wave functions. This gives the result, $\Delta E_H=1057.77\pm0.13$ Mc, which is in agreement with experiment.[2]

* Supported by the U. S. Air Force Office of Scientific Research.
[1] E. E. Chambers and R. Hofstadter, Phys. Rev. **103**, 1454 (1956).
[2] Triebwasser, Dayhoff, and Lamb, Phys. Rev. **89**, 98 (1953).

L10. Direct Formulation of Causality Requirements on the *S* Operator. I. E. SEGAL, *University of Chicago.*—The causality assumption that outgoing particles can be observed only when there have previously been incoming particles may be formulated mathematically as the assertion that the S operator leaves invariant the manifold M of all states describing an assembly of particles whose wave functions vanish on a backward ray. Equivalently, the marrix elements of S are restricted by the condition $PSP=SP$, where P denotes the projection onto M. This implies that the forward scattering amplitude for a scalar particle, as a function of the characteristic momentum $k_0-k_1(k_0{}^2-k_1{}^2=m^2)$, can be holomorphically extended to the upper half-plane, and satisfies essentially the Kramers-Kronig relation, the scatterer being relatively arbitrary. When it is the field of another scalar particle, Lorentz invariance implies further that the amplitude may be expressed as a function of the energy that is holomorphically extendable to the entire plane with infinite cuts on the real axis and satisfying crossing symmetry. Transformation from characteristic momentum to energy carries the original dispersion relation into one in terms of physical energies, whose kernel depends explicitly on m, and is of a character indicating rapid growth of the amplitude in the real unphysical energy region, but does not involve an adjustable parameter.

L11. Nucleus Model. JOSEPH G. BARREDO,* *C.S.I.C.*—Born has suggested the necessity of redefining the concept of particle. It was redefined[1] as the configuration formed by a carrier in front of a dipole, in order to avoid the timeless jumps of quantum electrodynamics. This configuration, called a trion, allows the elementary particle to have its own internal structure, as suggested by de Broglio, and gives the velocity of formation of quanta as "fusion" of elementary particles. Based on the trion concept, a nuclear-force model is proposed

now, which *avoids*, among others, the hypothesis that nuclear forces act between pairs of nucleons only, are always attractive, independent of the type of nucleons, and central. The model of force is given by the equation $F=e^2/x^2-e^2/(x+d)^2$ in which d is the distance between the two poles of the elementary particle, x the distance between the dipole and the carrier in front of it, and e the elementary charge. The corresponding binding energy is $E=e^2/x-e^2/x+d$, which gives 2.1 Mev for the deuteron binding energy, if the radius of the deuteron is taken as $1.4\cdot10^{-13}$ cm, and x as $0.7\cdot10^{-13}$ cm, which corresponds to the maximum binding energy.

* Now at the University of Chicago.
[1] M. Born, Science **122**, N3172, 675 (1955), J. G. Barredo, Bull. Am. Phys. Soc. Ser. II, 1, 85 (1956); Naturwiss. **15**, 346 (1956).

FRIDAY AFTERNOON AT 2:00

Engineering Auditorium

(W. S. HUXFORD presiding)

General Electron Physics

Invited Paper of the Division of Electron Physics

M1. Structure in Magnetically Confined Electron Beams. H. F. WEBSTER, *General Electric Research Laboratory.* (30 min.)

Contributed Papers

M2. Evaluation of Polycrystalline Hafnium as a Thermionic Emitter. M. D. GIBBONS, *General Electric Research Laboratory* (introduced by V. L. Stout).—This study involves the determination of the spectral emissivity, emission constants, and the evaporation rate from hafnium. The metal used was prepared by the iodide process, and contained less than 1% Zr. Gas contamination of Hf during fabrication was avoided by cold processing and/or protective pack techniques. Using Worthing's tube technique, the normal spectral emissivity was measured with an optical pyrometer having an effective wavelength of 0.651 micron. The emissivity values range from 0.445 ± 0.005 at 1200°K to 0.425 ± 0.008 at 2000°K. Emission constants were measured for Hf wire using a cylindrical anode with guard rings. Zero field emission was obtained by means of Schottky plots in the temperature range of 1000 to 1600°K. The best data obtained from Richardson plots give a zero degree work function of 3.65 ev and an A constant of 31.9 amp cm^{-2} deg^{-2}. These emission constants were very sensitive to the environment. The evaporation of Hf was studied by a Langmuir technique. Quantities of metal evaporated were measured by x-ray emission spectrography. The evaporation rate W in g cm^{-2} sec^{-1} is given by $\log W=6.58-2.94\times10^4\,T$. These evaporation data show that the vapor pressure of Hf is slightly less than that of Mo. Hafnium's thermionic efficiency in terms of grams evaporated per unit electron emission is slightly greater than that of Th metal.

M3. Sputtering of Molybdenum by Inert Gas Ions of Low Energy.* R. C. BRADLEY, R. C. STABLER, AND A. ARAKENGY, *Cornell University.*—A high vacuum 6-in. radius 60° sector field mass spectrometer has been used to study particles ejected from a molybdenum surface under bombardment by inert gas ions of low energy (<1000 ev). The method is similar to one described recently by Honig,[1] and has general applicability both for the analysis of surfaces of solids and for the study of sputtering. Despite the relatively large energy spread of the ejected particles, the seven isotopes of Mo could be clearly resolved in both the Mo and the MoO_2 peaks. An important feature of the method is that there is inappreciable heating of the sample due to the ion bombardment; thus target temperature is left as an independent variable. Energy thresholds for sputtering were measured as a function of target temperature and are in good agreement with Wehner's "velocity-of-sound" formula.[2] For a given ion energy, the sputtering was observed to decrease monotonically as the target temperature was increased. A surprising result was the high percentage of ejected particles which bore a positive charge.

* Supported by the U. S. Air Force through the Office of Scientific Research of the Air Research and Development Command.
[1] Richard E. Honig, Bull. Am. Phys. Soc. Ser. II, 2, 34 (1957).
[2] Gottfried K. Wehner, Phys. Rev. **102**, 690 (1956).

M4. Study of SrO on Mo in the Temperature Range 1200–1500°K by the Field Electron Microscope.* J. A. CAPE, G. J. BALDWIN, AND E. A. COOMES, *University of Notre Dame.*—SrO evaporated onto the molybdenum point of a field emission microscope has been shown to migrate rapidly and to form a reproducible pattern at a temperature of 1200°K.[1] Observations have been made of the evaporation of SrO for coverages initially in excess of one monolayer and reveal a reproducible series of patterns identical for all evaporation temperatures between 1200 and 1500°K. A minimum of work function is found to occur with a definite transition pattern. At these temperatures, the highest emitting areas are found to be the regions surrounding the 100 and 111 planes. The activation energy for evaporation from these regions may be determined from observations of the time intervals required to reach definite patterns at various temperatures.

* This research was supported in part by the Office of Naval Research.
[1] P. W. Kruse and E. A. Coomes, Phys. Rev. **93**, 929(A) (1954).

M5. On the Electrical Stability and Life of Field Emission Cathodes.* J. P. BARBOUR,† R. W. STRAYER,† R. L. FLOYD,† E. E. MARTIN,† J. K. TROLAN,† AND W. P. DYKE,† *Linfield College.*—The use of an intermediate temperature to maintain a smooth, clean, field emission surface during pulsed operation at useful levels of duty cycle and power has been reported.[1] In the present work an additional, low-level, steady-state bias field is superimposed with two resultant advantages: first, a stable cathode geometry, and hence a stable current-voltage relationship, results when electrostatic forces balance surface forces to prevent cathode dulling; and second, cathode life is increased by an order of magnitude to observed values up to 1300 hours. The results of life tests are discussed, and

predicted values of maximum pulse length and duty cycle are presented.

* This work was supported by the Office of Naval Research.
† Now at the Linfield Research Institute.
[1] W. P. Dyke and W. W. Dolan, *Advances in Electronics and Electron Physics* (Academic Press, Inc., New York, 1956), Vol. 8, chapter entitled "Field Emission."

M6. Observation of Electron Plasma Oscillations. M. ETTENBERG.—Microwave oscillations have been observed in a magnetically focused electron beam which are dependent on the presence of gas at a pressure of 10^{-5} mm Hg. The beam was that of a high-gain traveling-wave tube amplifier and it is this amplifier which simplifies the observation. It is proposed that a traveling-wave tube structure is a convenient means for studying the characteristics of low-density plasmas.

M7. Waves in Ionized Gases. F. J. FISHMAN, *Harvard University* (introduced by R. J. Glauber).—A dispersion relation is obtained for small-amplitude transverse oscillations of an infinite homogeneous plasma in a uniform external magnetic field. The linearized equation corresponding to the BGK model[1] is used to find a dispersion relation for the whole range from "low" frequency to "high" frequency. The system is characterized by a set of internal frequencies—collision, plasma, and cyclotron frequencies of electrons and ions—whose relative magnitudes depend upon the physical conditions. A general dispersion relation is obtained in parametric form: dispersion relations for propagating modes, including the limting cases of magnetohydrodynamic and magneto-ionic behavior, are derived therefrom in explicit form. The nonlinear terms are now introduced and treated as a small perturbation providing cross-modulation between different frequencies and different transverse and longitudinal modes. The special case of transmission and reflection of "moderate amplitude" electromagnetic waves normally incident on a semi-infinite plasma is analyzed in this way. It is shown that the reflected wave includes a third harmonic component.

[1] Bhatnagar, Gross, and Krook, Phys. Rev. **94**, 511–525 (1954); E. P. Gross and M. Krook, Phys. Rev. **102**, 593–604 (1956).

M8. Atomic Beam Method for Measuring the Scattering of Electrons by Alkali Atoms.* K. RUBIN, J. PEREL, AND B. BEDERSON, *New York University*.—Cross sections for the scattering of low-energy electrons by alkalies are being investigated by a crossed beam technique. A rectangular atomic beam is hit from one side by an electron beam and the loss in intensity of the direct (unscattered) atomic beam yields the total cross section. The differential cross sections are obtained by an analysis of measurements made on the scattered atomic beam taking the atomic velocity distribution into account. Work is also in progress on the measurement of that part of the cross sections due to electron exchange. In this experiment the atomic beam is polarized by an inhomogeneous magnet (also serving as a velocity selector) before it enters the scattering region, and analyzed by a similar magnet after leaving. The amount of depolarization is a measure of exchange scattering since with exchange the atom may change its spin state. The second magnet can be rotated about the scattering center and the angular distribution of the exchange scattering measured. Preliminary results on potassium will be presented.

* Supported by the Office of Naval Research.

M9. Aberration and Focusing of Magnetic Sectors Having Fringing Fields.* D. F. DEMPSEY,† W. C. MILLER, AND B. WALDMAN, *University of Notre Dame*.—The third-order aberration and focusing with sector-shaped magnetic fields of sharply defined boundaries has been investigated in an earlier work.[1] The same method has been used to evaluate aberration and focusing by magnetic sectors with fringing fields. For magnetic sectors bounded by straight lines and having fringing fields which vary as a function of the perpendicular distance from the sector edge only, general first- and second-order focusing conditions for median plane trajectories will be given. The transverse aberration of order α^3 which occurs when only first-order focusing is present has also been evaluated.

* Assisted by the joint program of the Office of Naval Research and the U. S. Atomic Energy Commission.
† Now at Canisius College.
[1] D. F. Dempsey, Rev. Sci. Instr. **26**, 1141 (1955).

M10. Use of the Disappearing Filament Technique with the Reflectometer. PAUL E. CARROLL, *The Carborundum Company*.—The cylindrical reflectometer described by Prescott and Morrison[1] can be used with the disappearing filament technique. This gives one a gain in ease of measurement and calculation. The technique is accomplished by adjustment of the apparent background temperature T until the outline of the incandescent filament being measured disappears into the background. Then the apparent blackbody temperature of the filament and the background are equal, $T=S$. This gives one a fairly simple expression for the spectral emissivity, ϵ_λ, of the filament: $\epsilon_\lambda=\exp[C_2\lambda^{-1}(1/T-1/D)]$, where D is the apparent blackbody temperature of the filament when background is not illuminated. When conditions for disappearance are met in this way, the true temperature of the filament is given by T, the apparent blackbody temperature of the background.

[1] C. H. Prescott and J. Morrison, **Rev.** Sci. Instr. **10**, 36 (1939).

FRIDAY EVENING AT 7:00

University Dining Hall

(H. D. SMYTH presiding)

Banquet of the American Physical Society

After-dinner speakers to be announced.

SATURDAY MORNING AT 10:00

Engineering Auditorium

(E. B. HENSLEY presiding)

Oxides

Invited Papers of the Division of Electron Physics

N1. Physical and Chemical Properties of Solid Solutions of H, Li, and Zn in ZnO. J. J. LANDER, *Bell Telephone Laboratories.* (30 min.)

Contributed Papers

N2. Photoconductivity of ZnO. R. J. COLLINS AND D. G. THOMAS, *Bell Telephone Laboratories.*—The photoconductivity of single crystals of ZnO has been studied using light absorbed in the fundamental band at 300°K and 78°K. For crystals with dark conductivity of 0.002 $(\Omega\ \text{cm})^{-1}$ at 300°K, and diameter 0.006 in. changes of a factor of 5 in air are observed. These effects decay at room temperature at 10^{-2} mm of O_2 in hours, in air in minutes, and in wet O_2, instantaneously showing that light produces a surface effect. The conductance produced may be "frozen" and shows a temperature behavior similar to that reported by Thomas and Lander[1] for conduction in a space charge layer produced by adsorbed Zn on ZnO. Similar effects observed on sintered powders are ascribed to the desorption of adsorbed O_2 but this cannot account for the magnitudes observed here. The above suggests that holes produced by light are trapped by surface oxygen lattice ions causing their desorption and leaving an excess of Zn at the surface. This photolysis of ZnO is analogous to that of AgBr. A similar model has been briefly considered by Heiland.[2]

[1] D. G. Thomas and J. J. Lander, Bull. Am. Phys. Soc. Ser. II, **2**, 185 (1957).
[2] G. Heiland, Z. Physik **142**, 415 (1955).

N3. Photoconductivity in MgO Crystals.* W. T. PERIA, *University of Minnesota* (introduced by A. J. Dekker).—It has been found that the photoconductivity of MgO crystals can be resolved in 2 bands centered at 4.05 ev and 5.05 ev. Prolonged irradiation in the 5.05-ev band greatly enhances the photoconductivity at lower energies, as previously reported by Day.[1] By probing the space charge field set up by such an irradiation it has been determined that excitation in the 5-ev band produces free electrons. A similar experiment showed that excitation in the 4-ev band produces free holes. Examination of the photoconductivity of x-rayed crystals showed that apparent peaks at 3.6 and 4.8 ev are due to a strong absorption at 4.3 ev. When the data were corrected for this effect no peaks were found in this energy region.

* Supported by a U. S. Air Force Contract.
[1] H. Day, Phys. Rev. **91**, 822 (1953).

N4. Photoelectric Emission from Barium Oxide.* J. E. DUEKER AND E. B. HENSLEY, *University of Missouri.*—A magnetic velocity analyzer tube for studying the energy distributions of photoemitted electrons has been described by Philipp.[1] Recent modifications on the design of these tubes and associated apparatus has resulted in somewhat better resolution. Measurements on BaO cathodes of relatively low activation ($J_0 = 4.68 \times 10^{-6}$ amp/cm² at 1000°K) show considerable structure in both the total quantum yield curves and the energy distribution curves. Structure in the low-energy region of the yield curves is indicative of direct excitations of electrons from several impurity levels. Structure in the higher energy region, where the emission is associated with a two-step process involving excitons, appears to agree with the structure observed by Zollweg[2] for the optical absorption due to excitons. In the energy distribution curves, several "fast" peaks (peaks that increase in kinetic energy when the incident photon energy is increased) can be correlated with the direct excitation structure observed in the low-energy region of the yield curves.

* Supported in part by the Office of Naval Research.
[1] H. R. Philipp, Phys. Rev. **94**, 777(A) (1954).
[2] R. J. Zollweg, Phys. Rev. **97**, 288 (1955).

N5. Thermoelectric Effect and Electrical Conductivity of Calcium Oxide.* H. H. GLASCOCK AND E. B. HENSLEY, *University of Missouri.*—The qualitative similarity of measurements of the electrical conductivity and thermoelectric effect of sprayed aggregates of CaO to measurements made on (BaSr)O by Young[1] suggest that CaO is also a pore conductor. The experimental tube design was similar to that used by Young. $CaCO_3$ was sprayed onto planar Ni cathodes which were mounted with their coated surfaces in contact. The carbonate was reduced to the oxide by heating in vacuum. Measurements were made in the temperature range from 650°K to 1250°K. In general the conductivities were much lower than for (BaSr)O but for the higher states of activation the characteristic break observed in the latter also occurred for CaO. Typically this break was at about 900°K. Measurements of the thermoelectric effect for CaO were much more difficult because of this low conductivity. Plots of the thermoelectric power *vs* the reciprocal temperature exhibited a maximum in the neighborhood of 1100°K and dropped sharply in the vicinity of the break in the conductivity curve. The shape of the thermoelectric curve was very similar to the case of (BaSr)O.

* Supported in part by the Office of Naval Research.
[1] J. R. Young, J. Appl. Phys. **23**, 1129 (1952).

N6. Electrolytic Processes in Oxide-Coated Cathodes.* KOJI OKUMURA AND E. B. HENSLEY, *University of Missouri.*—Three fine probes were placed at approximately equal intervals through a 1-mm thick coating of (BaSr)O between two heated, pure nickel electrodes. During the approximately 20 hours required for electrolytic activation (10 volts between electrodes and at a temperature of 1100°K) the dc conductivities of the four sections were automatically sampled at 2½ minute intervals. At less frequent intervals, the I–V characteristics of each section were recorded on a camera equipped oscilloscope by applying approximately four millisecond, triangular pulses of ±45 volts. Before applying the dc activating voltage, both electrode sections showed rectification characteristic of the oxide being a *p*-type semiconductor; both center sections had linear I–V curves. After applying the dc activating voltage, the negative electrode section became

slightly *n*-type as indicated by its I–V curve, the positive electrode section increased its *p*-type characteristics. After considerable activation the negative and positive electrode sections were strongly *n*-type and *p*-type, respectively, with the *n-p* transition extending into the two center sections as indicated by their nonlinear I–V curves. When fully activated, both electrode sections showed *n*-type rectification while both center sections again had linear I–V curves. Implications with regard to the activation process will be discussed.

* Supported in part by the Office of Naval Research.

N7. On the Theory of Secondary Emission.* A. J. DEKKER AND R. G. LYE, *University of Minnesota.*—In the elementary theory of secondary emission it has usually been assumed[1] that the energy losses suffered by the primary electrons are governed by the Whiddington law. Furthermore, it is assumed that all primary electrons have the same penetration depth. The theory based on these assumptions leads to a secondary yield *versus* primary energy curve which deviates markedly from experimental curves. Recent measurements[2] of the energy dissipation of relatively slow electrons in solids indicate, however, that the assumptions mentioned above are incorrect. It will be shown that a theory which incorporates these recent results gives considerably better agreement with experiment.

* Work supported by a U. S. Air Force Contract.

[1] H. Bruining, *Physics and Applications of Secondary Electron Emission* (McGraw-Hill Book Company, Inc., New York, 1954), chapter 6.

[2] J. R. Young, Phys. Rev. 103, 292 (1956); and a paper by the same author to be published shortly.

SATURDAY MORNING AT 10:00

Law Auditorium

(J. W. BEAMS presiding)

Invited Papers

P1. Recent Work with High-Temperature Shock Waves at the University of Michigan. O. LAPORTE, *University of Michigan.* (30 min.)

P2. Cooling by Adiabatic Rotation. J. C. WHEATLEY, *University of Illinois.* (30 min.)

P3. Nuclear Magnetic Resonance and Crystal-Structure Problems. R. D. SPENCE, *Michigan State University.* (30 min.)

P4. Nuclear Spin Relaxation in Superconductors. L. C. HEBEL, *University of Illinois.* (30 min.)

SATURDAY MORNING AT 9:30

Nieuwland 127

(W. C. MILLER presiding)

Invited Papers

Q1. Electron Scattering. B. WALDMAN, *University of Notre Dame.* (30 min.)

Q2. Level Widths as Obtained from Nuclear-Reaction Studies. C. P. BROWNE, *University of Notre Dame.* (30 min.)

Q3. Nuclear Levels of Rare-Earth Isotopes. J. W. MIHELICH, *University of Notre Dame.* (30 min.)

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Yamasaki, R. S.—J1

Zitter, R. N.—K6

Preliminary Announcement of the 1957 Summer Meeting in the West

The summer meeting of the American Physical Society in the West is to be held at the University of Colorado in Boulder, on September 5, 6, and 7, 1957. The University of Colorado and the Boulder Laboratories of the Bureau of Standards will be co-hosts. The deadline for contributed papers for this meeting is Monday, July 8. Abstracts are to be sent to Dr. William A. Nierenberg, Department of Physics, University of California, Berkeley 4, California.

Boulder is located at the base of the eastern slope of the Rockies, twenty-seven miles from Denver via a fast toll road. Frequent bus service is provided between downtown Denver, or the railway station in Denver, and Boulder, and the buses stop at the campus. Special trips to points of interest in the area, including the Bureau laboratories and the coronagraph in the University High Altitude Observatory at Climax, are planned. Boulder is thirty-four miles from Estes Park Village and the scenic attractions of Rocky Mountain National Park and the Continental Divide.

At the present time, sessions of invited papers are planned on Atomic Clocks and Microwave Physics, Low-Temperature Physics, Low- and High-Energy Physics, Solid-State Physics, Theoretical Physics, and Cosmic-Ray Physics.

Housing will be available in local motels and hotels and in the University residence halls. The residence halls are close by and can accommodate any reasonable number of guests. For any of these accommodations, please write Mr. Clifford Yoder, Director of Men's Residence Halls, University of Colorado. Mr. Yoder will make reservations for the residence halls and will supply a list of local hotels and motels and the rates. Reservations should be made directly to the hotels and motels.

Preliminary Announcement of the 1957 Thanksgiving Meeting at St. Louis

As happens every few years, so in 1957 the Thanksgiving meeting of the American Physical Society is transposed from its more usual habitat to Washington University, St. Louis. The dates will be Friday and Saturday, November 29 and 30, 1957. Rooms have been set aside for our members, at the flat rates of $7 for singles and $13 for twin beds, in the Coronado Hotel, 3701 Lindell Boulevard.

Deadline will be Friday, September 27. Abstracts are to be sent to Karl K. Darrow, American Physical Society, Columbia University, New York 27, New York.

Announcement of the Tenth-Anniversary Meeting of the Division of Fluid Dynamics

The Division of Fluid Dynamics of the American Physical Society will hold its tenth-anniversary meeting at Lehigh University, Bethlehem, Pennsylvania, on Monday, Tuesday, and Wednesday, November 25, 26, and 27. Deadline is Friday, October 11. Abstracts are to be sent to Dr. F. N. Frenkiel, Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Maryland. Notices will be sent to members of the Division.

MEETINGS AND DEADLINES UP TO THE 1958 ANNUAL MEETING

Place	*Meeting dates*	*Deadline date*
Notre Dame, Indiana	June 20–22	past
Boulder,* Colorado	September 5–7	July 8
St. Louis	November 29–30	September 27
Stanford,* California	December 19–21	October 18
New York	January 29–February 1	November 15

* Abstracts for the Boulder and Stanford meetings are to be sent to W. A. NIERENBERG, University of California, Berkeley 4, California, and must reach his office not later than the corresponding deadline date.

Abstracts for the other meetings listed above are to be sent to KARL K. DARROW, American Physical Society, Columbia University, New York 27, New York, and must reach his office not later than the corresponding deadline date. Take note that abstracts mailed the day before deadline-day often fail to arrive in time: the last postal delivery of the day usually comes to our office before 2 P.M. Allow at least two days for abstracts sent by airmail from points east of the Mississippi, and longer for those sent from farther west. To avoid chance of confusion, please do not send an abstract for any meeting until the deadline date of the previous meeting is at least five days past. *The privilege of contributing papers to meetings of the American Physical Society is restricted to the members of the Society and to nonmembers whose papers are sponsored by members.*

RULES AND INSTRUCTIONS FOR THE PREPARATION OF ABSTRACTS

The Council has ordered that abstracts shall be not longer than two hundred (200) words or the equivalent thereof. In reckoning equivalence, a footnote is equated to ten words; each line in a table to ten words; a "display" formula—one that requires a line to itself—is an expensive luxury equated to forty words.

Two copies of each abstract must be sent to the appropriate office. They must be typewritten; one must be an original, the other may be an original or a carbon copy. *They must be double-spaced:* single-spaced manuscripts are too crowded to permit the editorial markings to be made with ease and clearness. Each abstract must be confined to a single page: if it is too long for a single page it is too long to be printed. *If we receive an abstract typed on two pages, we print only its first page.* Write each abstract as a single paragraph: the suppression of paragraphs costs time and labor to the editors. Do not use very thin paper; a sheet of very thin paper may cause extraordinary trouble when mixed with sheets of reasonable thickness. Look at the abstracts in this *Bulletin* to see how the title of the paper and the name of the author are to be arranged, and follow the example. Issues of the *Bulletin* are always appreciably delayed because the editors have to do what the authors should have done.

Remember the rule of the Council that, if an author submits more than one abstract, all but one must go onto the Supplementary Programme. In enforcing this rule, an abstract is credited to the author whose name appears first in the by-line. **By action of our Council, abstracts will not henceforth be withdrawn from our proofs unless the asker sends ten dollars with his request.**

Next winter we shall begin to levy a stiff charge for all corrections made upon text or proofs of abstracts, since these have become so numerous as to delay the *Bulletin*. Start now to form the habit of getting your abstract right before you send it in.

Proceedings of the American Physical Society

Minutes of the Meetings Held in March, 1957

THE **first** March meeting of 1957 was held in **Norman, Oklahoma,** at the University of Oklahoma, on Friday and Saturday, March first and second. This was one of our "firsts"—the first meeting ever held by the American Physical Society in the state of Oklahoma. The attendance justified the expectations of the Local Committee and surpassed the hopes of the Secretary. Two hundred and seventy-two people registered, and it was conjectured that there might have been more but for rains that wetted the highways. There were fifty-two contributed papers. The invited papers covered a wide range of topics, with a notable number of subjects of geophysical interest (as is the custom of our Southwestern meetings) and also a symposium on fluid dynamics. The University of Oklahoma put excellent halls at our disposal, and enabled our members to visit the DeGolyer Collection of books on the history of science. To its Local Committee, and particularly to the Chairman, J. Rud Nielsen, the thanks of the Society are offered.

The banquet was held on Friday evening in the ballroom of the Memorial Union of the University with an attendance of 154. We were graciously welcomed to the University of Oklahoma by its President, G. L. Cross, and then were spellbound by a remarkably interesting address by Laurence Snyder, professor in the University and President of the AAAS: its title was "Heredity and Modern Life."

The **second** March meeting of 1957 was held in **Philadelphia,** at the University of Pennsylvania, on Thursday, Friday, and Saturday, March 21, 22, and 23. This was the 1957 member of the March sequence adopted as their own by our Division of High-Polymer Physics and our Division of Solid-State Physics, to which was added on this occasion the Division of Chemical Physics. All of these provided symposia and other invited papers, and the two first-named elicited large numbers of contributed papers in their respective fields. The other fields of physics mustered two sessions of contributed papers (we are anomalously considering liquid helium as a phenomenon of solid-state physics, since the Division of Solid-State Physics has adopted it) and a group of four invited papers. The total number of contributed papers was 213 (not a record). The attendance set a new record for a March meeting, and probably a record for any meeting of the Society other than those held in Washington and in New York or Boston: there were a thousand and eighty-three registrants. Two large auditoriums of the University were put at our disposal, as well as several classrooms.

The banquet was held on Friday evening: it is painful to record that the attendance was only 161: apparently there are too many famous restaurants in Philadelphia. The after-dinner speakers were our fellow-member, the President of the University of Pennsylvania, Gaylord P. Harnwell; and T. G. Fox, Cyril S. Smith, and G. Herzberg of the three Divisions, Smith speaking under the title "Physical Metallurgy and the Physics of Metals." On Thursday afternoon there was a social two-hour period, with beer, in a stately hall of the University Museum (vividly characterized by one of our members as a "smoke-filled tomb"): during part of it the executives of the Division of Solid-State Physics could be seen trying hard to hold a business meeting of their Division.

The Council of the Society held a brief meeting on Thursday and elected to Membership the one-hundred sixty-nine candidates whose names are appended.

For the management of this big meeting we are greatly indebted to C. W. Ufford, Chairman of the Local Committee, and S. D. Morgan of the Department of Physics of the University of Pennsylvania.

K. K. D.

Elected to Membership in the American Physical Society on March 21, 1957: Tore N. Anderson, Noubar M. Arpiarian, Anthony Arrott, [a]Gianni Ascarelli, Tamotsu Awano, [a]William D. Barber, Frederic E. Bellas, N. Paul Bosted, [a]Richard Irwin Brown, John Edwin Bubser, Richard Michael Carbone, [a]David L. Carter, R. G. Chambers, [a]Bernard M. Chasan, [a]Seong C. Cheong, John Washington Childress, III, [a]Hong-Yee Chiu, Nicholas C. Christofilos, Roger W. Clapp, Jr., M. H. Cocks, C. Tristram Coffin, Herbert A. Cohen, [a]Stephen Richard Cottrell, [a]Monroe J. Cowan, Ernst R. Czerlinsky, Wilfried W. Dähnick, Stanley G. Davis, [a]John Paul Delvaille, [a]Edward Augustine Desloge, Sobhana Dhar, Kenneth B. Earnshaw, Donald E. Ehlers, Frederick K. Ehrenburg, Daniel M. Ekstein, [a]Rolf Engleman, Jr., [a]Thomas Erber, [a]Allen E. Everett, Hugh Everett, III, Raymond L. Farrow, Irwin Feerst, [a]Martin Feldman, [a]Richard W. Fessenden, L. L. Foshee, Tadao Fukuroi, [a]Yun-Tong Fung, Nicholas Fuschillo, [a]Paul J. Gans, [a]Donald A. Garrett, [a]Luis Maria Garrido, Robert V. Garver, [a]Duane C. Gates, Lawrence J. Giacoletto, Francis R. Gleason, Jr., Lucien R. Godefroy, [a]Stanley A. Golden, [a]Lester K. Goodwin, [a]William H. Goodyear, Adon A. Gordus, Mauricio Grinberg, Josef Gschwendtner, C. W. Gullikson, John Halpern, Donald R. Hamilton, Arthur R. Harmeyer, Richard S. Harner, [a]Edward L. Hart, John Hart, Alfred E. Hawkins, [a]Dwight S. Heim, John Harmon Henkel, [a]John Charles Hensel, [a]William B. Herrmannsfeldt, Chester A. Hines, [a]Fred N. Holmquist, Raymond M. F. Houtappel, [a]Paul S. Hubbard, Albert Huebner, [a]Fred Winston Inman, W. S. Jarnagin, [a]Coates Richard Johnson, Carleton H. Jones, Jr., [a]Joseph J. Kepes, [a]James King, Jr., [a]John R. Klauder, Max Klein, Jack Kline, Thomas G. Knorr, [a]Daniel

S. Koltun, Toshimoto Kushida, *†Harold O. Ladd, *Paul H. Lasky, Tavorath K. Lakshmanan, Arthur Langridge, Leo W. Lemley, *Leonard Phillip Levine, Ching Y. Liang, William A. Little, *David Bishop Lombard, *Eugene J. M. Lynch, Morris Saul Macovsky, *John Owen Maloy, Donald L. Manley, Marion J. Marcinkowski, Thayer E. Masoner, *F. Scott Mathews, Endre A. Mayer, *James A. McCray, Peter Meyer, John B. Miles, Kazuko Mochizuki, Pierre Morel, Mark Lewis Naiman, William Basil Nefedov, *Michael Nessin, Jack Norman Nielsen, *Alice A. Padgett, *M. Lee Page, Ralph F. Penoyer, John Wright Peterson, Charles Pine, Edward Poindexter, Richard Possamai, *Edward Prenowitz, Richard J. Prosen, Wade A. Renn, Herbert L. Rest, John L. Rogers, *Gerald H. Rosen, Laura M. Roth, *Henry Ruderman, J. Ray Ruetenik, B. J. Sandlin, *Loren C. Schmid, Frank Henry Schmitt, *Robert Schor, Robert Thomas Sharp, Richard C. Sherwood, K. Shimomura, *Abner Eliezer Shimony, *William Walter Simmons, Morris Albert Steinberg, *Richard Moritz Stern, John Robert Streetman, Iain Balfour Strong, *Billy S. Thomas, *T. Darrah Thomas, Joseph J. Tobias, Soitiro Tosima, *Warren C. Tyler, Ludwig K. van Rossum, Charles A. Velaer, Jr., *Britton Thomas Vincent, Jr., Milton M. Wachtel, *R. H. Woodward Waesche, *John R. Waters, Fleur B. Wang, Arthur D. Warren, *Marvin J. Weber, Matthew Judson White, Jr., John R. Wieneke, *Spencer Lynn Williams, *Charles R. Willis, *Dale R. Winder, John W. Winslow, *Jack Dallas Wolf, *Arthur Yelon, Dino Zei, and *Sigi Ziering.

† One sponsor.

Errata Pertaining to Abstracts A8, E8, and J1 of the 1957 Norman, Oklahoma, Bulletin (Series II, Volume 2, No. 2)

A8, by Selby M. Skinner, E. L. Kern, M. K. Park, and N. M. Trivisonno. The following footnote should be added: "With the support of the Aeronautical Research Laboratory, Wright Air Development Center, Air Research and Development Command, U. S. Air Force."

E8, by J. O. Parr, Jr. In line 12, omit the word "be."

J1, by R. W. Fink. In line 5, instead of "$L_\alpha:L_\beta:L_\gamma::1.1:0.19$," read "$L_\alpha:L_\beta:L_\gamma::1.0:1.1:0.19$."

Errata Pertaining to Abstracts C7, CA6, LA5, R1, and Z1 of the 1957 Philadelphia, Pennsylvania, Bulletin (Series II, Volume 2, No. 3)

C7, by M. Balkanski. In line 9, instead of "$D+100$ cm^2/sec" read "$D\sim100$ cm^2/sec." In line 14, instead of "was done in the Fritz Haber Institut (Berlin) by Dr. I. Broser," read "was done in the laboratory of Dr. I. Broser at the Fritz-Haber-Institut (Berlin)."

CA6, by D. B. Fischbach. In line 10, instead of "goes through a minimum near 450°C, then rises," read "goes through a minimum near 400°C, then rises." In line 22, instead of "The grain boundary peak is located above 800°C," read "The grain boundary peak is located near 700°C."

LA5, by Hiroshi Sato. In line 1, instead of "Resistivity of Au_3 at," read "Resistivity of Au_3Cu at." In line 7, instead of "nearly the same temperature range," read "nearly the same in the same temperature range."

R1, by W. J. Van Sciver and L. Bogart. In line 21, instead of "the value $14.1\pm0.7\%$ is obtained," read "the value of $15.1\pm0.8\%$ is obtained."

Z1, by W. L. Brown and W. M. Augustyniak. In line 20, instead of "compared with the lifetime threshold of 0.5 Mev reported by Loferski and Rappaport and the earlier conductivity threshold of 0.63 Mev determined by Klontz and Lark-Horovitz," read "compared with the lifetime threshold of 0.325 Mev reported by Loferski and Rappaport and the earlier conductivity threshold of 0.63 Mev determined by Klontz and Lark-Horovitz."

Minutes of the Meeting of the Southeastern Section Held at the University of Kentucky, Lexington, Kentucky, April 4, 5, and 6, 1957

The twenty-third meeting of the Southeastern Section of the American Physical Society, held at the University of Kentucky on April 4, 5, and 6, 1957, was attended by about 300 physicists from the region. The arrangements at the University of Kentucky were made by Bernard Kern; the program was planned by another committee chaired by Vincent Parker. The program of 27 invited and 60 contributed papers appears below. Nine additional papers related to physics teaching are recorded in the *American Journal of Physics*. The dinner address was given by John R. Dunning of Columbia University; the papers by Paul McDaniel and Arthur E. Ruark were presented at another evening session. During the meeting the Section chose the Redstone Arsenal, Huntsville, Alabama, as the site of its 1958 meeting on April 10, 11, and 12. The Section also elected the following as its officers for 1957–1958: Robert Lagemann, Vanderbilt University, chairman; Irving Foster, Virginia Military Institute, vice-chairman; Howard Carr, Alabama Polytechnic Institute, secretary; Myron McKay, University of Chattanooga, treasurer; and Eric Rodgers, University of Alabama, executive committeeman. Dixon Callihan, of the Oak Ridge National Laboratory, is the retiring chairman.

Howard Carr, *Secretary*
Southeastern Section
American Physical Society

Symposium on Low Temperature Physics

(J. M. REYNOLDS presiding)

Invited Papers

A1. Liquid and Solid He^3. WILLIAM M. FAIRBANK, *Duke University.* (30 min.)

A2. Some Experiments on the Tensile Strength of Liquid Helium. J. W. BEAMS, *University of Virginia.* (30 min.)

A3. Studies in Solid State Physics at Low Temperatures. C. F. SQUIRE, *Rice Institute.* (30 min.)

A4. Effects of Elastic Deformations on Superconductivity. CLAUDE GRENIER, *Louisiana State University.* (30 min.)

A5. Superconductivity at Microwave Frequencies. WALTER GORDY, *Duke University.* (30 min.)

Biophysics

(JOHN S. KIRBY-SMITH presiding)

B1. Study of the Effects of Varying Concentrations of Na and K on Trace Element Determinations in a Biological Tissue Ash. CHARLES A. BOYE, JR., *Tennessee Eastman Company,* AND ISABEL H. TIPTON, *The University of Tennessee and Oak Ridge National Laboratory.*—In the program of analysis of human tissue by emission spectrography, one set of standards has been used for the analysis of all types of soft tissues. Since these tissues vary somewhat in concentration of major constituents, sodium and potassium, it was felt that a study should be made on the effects of varying concentrations of sodium and potassium on the determination of trace elements. Matrices containing concentrations of potassium in the ratio K/Na of 0.344, 0.680, 1.24, 2.36, 5.72 were mixed and the effects of these variations on the elements Cd, Cu, Mn, Mo, Pb, Sn, and Zn were measured. No significant effect on the determination of these elements was observed.

B2. Relative Effects of Gamma Rays, Fast Neutrons, and α Particles on Free Radical Production. J. S. KIRBY-SMITH AND M. L. RANDOLPH, *Oak Ridge National Laboratory.*—A study of the relative efficiency of the free radical production by various ionizing radiations on simple biochemical systems has been carried out. Free radicals produced by the action of 1.17- and 1.3-Mev cobalt-60 gamma rays, 1.4-Mev fast neutrons from the D-T reaction, and 5.3-Mev α particles from polonium have been studied by paramagnetic resonance techniques. These radiations of widely different linear energy transfer (LET) give the same resonance patterns in irradiated amino acids, but show the expected large variation in number of uncoupled electron spins produced per unit energy absorbed. For glycine, the relative efficiency of gamma rays, fast neutrons, and α particles is in the ratio 1:0.7:0.1. These measurements show clearly the wastage of ionization in the case of free radicals induced by the particulate radiations of high LET values. The possible interpretation of the relative biological effectiveness (RBE) of various ionizing radiation of different LET will be discussed briefly in terms of these results.

B3. Interactions of 14.1-Mev Neutrons with Biological Tissue. M. L. RANDOLPH, *Oak Ridge National Laboratory.*—A description, adequate for quantitative radiobiology, of the first collision interactions and energy dissipation resulting from the irradiation of biological tissue with 14.1-Mev neutrons, copiously available from the $H^3(d,n)He^4$ reaction, should indicate per unit flux the total dose rate, the dose rate due to each ionizing product formed, and the distribution or at least a well-defined average of the linear energy transfer (LET) of all the ionizing products. The calculation of these quantities requires prior knowledge of all the reactive nuclear cross sections for 14-Mev neutron interactions with H, C, N, and O, the differential cross sections for neutrons scattered by these elements, quantitative values for the rate of energy loss of nuclei at energies less than that at the Bragg peak, and elementary composition of the irradiated medium. Calculations have been made, with allowance for these considerations, of the dose rate to flux ratio, track average LET, defined as $\int L\xi(L)dL/\int\xi(L)dL$, and energy average LET, defined as $\int L\Theta(L)dL/\int\Theta(L)dL$, where $\xi(L)dL$ and $\Theta(L)dL$ are the fractions of total track length and total energy of particles as they pass through the LET range dL. The importance of each complicating consideration mentioned previously will be discussed.

B4. Magnetically Suspended Equilibrium Ultracentrifuge.* J. W. BEAMS, W. C. SIMPSON, AND K. D. WILLIAMS, *University of Virginia.*—Some improvements in the magnetically suspended equilibrium ultracentrifuge[1] are described. Due to the excellent thermal insulation and extremely low friction of the magnetically suspended "coasting" highly polished ultracentrifuge rotor, the rotor temperature fluctuates less than the metal walls of the vacuum chamber which surround it. The temperature of the chamber is measured and held constant to about one part in 10^4. The speed of the "coasting" rotor is free from hunting and can be determined to one part in 10^6. The Jamin-type interferometer previously described for measuring sedimentation has been markedly improved by making use of three light beams instead of two. One beam passes through the solution and the other two through the solvent. Three separated fringe patterns each superimposed on an image of the centrifuge cell are produced. This provides reference fringe sets from which fringe movement due to sedimentation can be determined with greater reliability. A shift of about 0.003 fringe can be observed. A modified Twyman type interferometer also is being developed.

* Supported by National Science Foundation.

[1] Beams, Dixon, Robeson, and Snidow, J. Phys. Chem. 59, 915 (1955).

Invited Paper

B5. Realities in Biophysics. CHARLES W. SHEPPARD, *Oak Ridge National Laboratory.* (30 min.)

Experimental Techniques and Apparatus

(B. D. KERN presiding)

C1. Compact, Pressurized 2-Mev Electrostatic Accelerator. T. M. HAHN, JR., A. ROBESON, AND J. L. RYAN, *Virginia Polytechnic Institute.*—A small pressurized accelerator with a design limit of 100 microamperes at 2 Mev has been completed and will be described. This installation utilizes a horizontal accelerator column in a readily available, removable pressure tank 4 feet in diameter and 10 feet long. Operating pressure is 150 psig. Support members are Textolite tubes, with an insulating length of 3 feet. A Moak type radio-frequency ion source is used. Power for the source and associated circuits is supplied by a 500-watt permanent magnet alternator. Voltage stabilization is effected through a 90 degree magnetic analyzer and corona feedback system. Provision has been made for conversion to 4 Mev with a vertical accelerator column in a new building.

C2. Versatile, Natural-Uranium Subcritical Assembly.* T. M. SCHULER, JR., A. ROBESON, AND T. M. HAHN, JR., *Virginia Polytechnic Institute.*—An exponential assembly utilizing 30 000 pounds of AGOT grade reactor graphite and 2500 pounds of natural uranium has been constructed and will be described. A 15-curie polonium-beryllium source is used as a neutron source. Design considerations, constructional details, and performance data will be given. Results of measurements of the diffusion length, Fermi age, and material buckling will be presented. Experience with the use of this installation in reactor training programs will be given. Plans are underway for the use of a pulsed neutron source with this assembly.

* Supported in part by the U. S. Atomic Energy Commission.

C3. Preparation of Thin, Uniform Sources for a Beta-Ray Spectrometer. R. L. BLANCHARD,* B. KAHN,* AND R. D. BIRKHOFF, *Oak Ridge National Laboratory.*—The nonuniform activity distribution found in sources prepared by evaporation of a radioactive solution indicated a need for other methods. Radiocolloidal sorption and electrodeposition of ruthenium-106, silver-110, mercury-203, cobalt-60, indium-114, chromium-51, iron-57, gold-198, iridium-192, and selenium-75 produced uniform deposits as indicated by radioautographs. Sources were prepared on a 25 $\mu g/cm^2$ Formvar-polystyrene film made conducting by the vacuum evaporation of 30 $\mu g/cm^2$ of gold onto the surface. A gold-199 source was obtained by irradiating platinum metal in the ORNL-LITR, and then allowing the decay of platinum-199 to gold-199. The gold-199 was extracted from 6 *M* HCL into ethyl acetate, evaporated to dryness, redissolved in 0.5 *M* aqua regia, and deposited onto the gold film at 4 volts and 50 ma/cm^2. The K and L lines of the 159-kev and 209-kev gamma rays were examined in a solenoidal magnetic spectrometer. The peaks were symmetrical at a momentum resolution of 0.2% thus giving evidence for uniformity of deposition and low solid content of the source.

* U. S. Public Health Service, assigned to the Health Physics Division at ORNL.

C4. Preliminary Study of Post-Acceleration in a Beta-Ray Spectrometer. W. T. ACHOR,* A. W. SMITH,† AND S. K. HAYNES, *Vanderbilt University.*—Reduction of counter window thickness to $\sim 3\ \mu g/cm^2$ permits the measurement of relative intensities of electrons down to ~ 2.5 kev with a beta-ray spectrometer.[1] One method of extending the usable range to zero kinetic energy is post-acceleration. A disadvantage of this method, as shown previously,[2] is the production of spurious counting as a function of accelerator voltage. This study indicates that below 5 kv, while there is some increase in counting rate with no source present, none of the spurious counting is due to electrical discharges, and most is due to low-energy electrons multiply-scattered from the source (Cs^{137}). Use of the ionization gauge tube as a source of low-energy electrons confirms the latter conclusion. Factors tested which have no effect on the operation of the accelerator below 5 kv are temperatures (10–25°C) and spectrometer pressure (2×10^{-6}–2×10^{-4} mm Hg). Use of a grid instead of an open hole as ground electrode gave some evidence of more stable operation. It is believed that more effective shielding of the counter from the source would allow satisfactory use of this method.

* Now at Western Reserve University.
† Deceased.
[1] Burford, Lafferty, Thomas, and Haynes, Bull. Am. Phys. Soc. Ser. II, 1, 260 (1956).
[2] K. Siegbahn (Editor), *Beta- and Gamma-Ray Spectroscopy* (Interscience Publishers, Inc., New York, 1955), p. 272.

C5. Fluorescent Response of CsI(Tl) to Nitrogen Ions. M. L. HALBERT, *Oak Ridge National Laboratory.*—The relative light output L of a CsI($\sim$0.1% Tl) crystal has been measured using nitrogen ions, α particles, and γ rays. The nitrogen ions, from the ORNL 63-inch cyclotron, were scattered through 90° by a gold target into the crystal. Energies less than the maximum cyclotron energy (27.9 Mev) were obtained by inserting nickel foils in the unscattered beam. The energy loss was calculated from the empirical range-energy relation.[1] Nitrogen ions give linear response up to $E\sim16$ Mev. At higher energies, L *vs* E is slightly concave. The pulse height at 16.5 Mev equals that for a 5.30-Mev α particle. The energy response for α particles was measured using a Po^{210} source and aluminum foils, the energy loss being obtained from experimental data.[2] The response is linear above $\sim$3.5 Mev and extrapolates to $\sim$1 Mev. For γ rays of 279.2 and 411.8 kev, L *vs* E is fit well by a straight line passing through the origin and parallel to the linear portion of the α response curve.

[1] Reynolds, Scott, and Zucker, Phys. Rev. **95**, 671 (1954).
[2] S. Rosenblum, Ann. phys. **10**, 408 (1928).

C6. The Response of the Anthracene Scintillation Counter to Monoenergetic Electrons. L. W. JOHNSTON, R. D. BIRKHOFF, J. S. CHEKA, H. H. HUBBELL, AND B. G. SAUNDERS, *Oak Ridge National Laboratory.*—An electron accelerator supplied monoenergetic electrons of energies between 10 and 120 kev. The beam was incident upon thin bare anthracene crystals centered on the photocathode of an RCA 6199 photomultiplier. The reflector consisted of a hollow truncated cone placed with the base concentric to the photocathode. An *A*-1 linear amplifier and single channel analyzer were used to obtain a pulse-height distribution at each energy. The peak pulse height is a linear function of the incident electron energy with intercepts of 4.5 kev and 3.5 kev for the 0.060-inch and 0.011-inch crystals, respectively. The pulse-height distribution could be fitted well with a Gaussian. The data indicate a linear relationship between the square of the width of the pule-height distribution at half-maximum and the electron energy. The average amount of electron energy absorbed in the crystal required to produce a photoelectron at the photocathode is 1.47 ± 0.08 kev/photoelectron for the 0.060-inch crystal and 1.32 ± 0.13 kev/photoelectron for the 0.011-inch crystal.

C7. Calutron Collections of Inert Gas Isotopes. H. B. GREENE, *Oak Ridge National Laboratory* (introduced by J. R. Sites).—In connection with the program of enriching stable

isotopes with the electromagnetic separators at Oak Ridge National Laboratory, experimentation has been undertaken to establish that ions of argon and neon produced with this equipment can be collected and retained on metal surfaces by means of adsorption. A technique has been worked out whereby target surfaces quickly saturated at ordinary reception rates can be renewed by continual or periodic vaporization of a suitable metal and condensation of this metal on the target. Subsequent outgassing of these targets for recovery of the collected isotopes yields many time more gaseous impurities than the desired product, and a practical system for cleaning the inert gases has been accomplished. Results of this work indicate that the less abundant isotopes which would typically be monitored at collection rates of a fraction of a milliampere can be recovered from the targets in amounts greater than 50% of the indicated collected amounts and in isotopic purities greatly enhanced over the natural abundance.

C8. Apparatus for Measuring Electron Attachment. T. E. BORTNER AND G. S. HURST, *Oak Ridge National Laboratory.*—The time variation of the electrostatic potential of a plane electrode ionization chamber, due to the motion of electrons in the uniform field, depends on the drift velocity of electrons and the attachment of the electrons to the gas in the chamber. If the pulse is examined with a linear pulse amplifier having suitable integration and differentiating time constants, the pulse height will be a simple analytical function of the attachment coefficient and the electron drift velocity. This information has been used to develop a pulse method of measuring electron attachment. In one section of a plane electrode ionization chamber the pulse height due to the motion of electrons, produced by alpha-particle ionization, is measured. Drift velocity of electrons is measured in another part of the same ionization chamber. These two measurements furnish data from which the attachment coefficient is calculated. Results on trace amounts of oxygen in various gases will be presented.

C9. Electron Attachment in O_2-N_2 Mixtures.* G. S. HURST AND T. E. BORTNER, *Oak Ridge National Laboratory.*—When trace quantities of O_2 are mixed with a nonattaching gas (for example, N_2), it is found that the attachment coefficient for O_2 depends on the pressure of O_2 as well as the pressure of the nonattaching gas. This behavior can be accounted for by assuming that the first step in the attaching process is the formation of O_3^-, and that stabilization of this vibrationally excited molecule takes place by collisions with either O_2 or N_2. By calculating the pressure dependence of the attachment coefficients when various kinds of stabilizing collisions are assumed and comparing the results obtained with the experimental data, one can develop a model which fits the data, and the relative cross sections for the various types of collisions can be determined. Our results predict that the attachment coefficient becomes independent of pressure at high concentrations of O_2, thus suggesting that the attachment coefficients measured by Bradbury[1] represent an asymptotic limit of the attachment process.

* This material will be submitted by G. S. Hurst as a part of a dissertation for the degree of Doctor of Philosophy at the University of Tennessee.
[1] N. E. Bradbury, Phys. Rev. **44**, 883 (1933).

Symposium on High-Energy Accelerators

(V. E. PARKER presiding)

D1. High-Energy Accelerators in Russia. JOHN MARSHALL, *University of Chicago.* (30 min.)

D2. Characteristics of Primary and Secondary Beams of the Bevatron. HARRY G. HEARD, *University of California.* (30 min.)

D3. Brookhaven 25-Bev Proton Synchrotron. JOHN P. BLEWETT, *Brookhaven National Laboratory.* (30 min.)

D4. Oak Ridge Cyclotron Analog. H. G. BLOSSER, *Oak Ridge National Laboratory.* (30 min.)

D5. Progress Report of the Southern Regional Accelerator Committee. S. K. HAYNES, *Vanderbilt University.* (30 min.)

Magnetism, Electricity, and Solid State

(T. H. BLEWETT presiding)

E1. Paramagnetic Resonance in X-Irradiated Sodium Chlorate. W. B. ARD, JR.,* AND W. G. MOULTON, *University of Alabama.*—Sodium chlorate which has been irradiated with 50-kv x-rays exhibits a rather complicated paramagnetic resonance spectrum. The spectrum seems to be made up of two groups of lines, an orientation dependent group and an orientation independent group. The orientation independent group appears to be the hyperfine structure of an unpaired electron coupled to the chlorine nucleus. The splittings and intensities of these lines is consistent with the nuclear magnetic moments and relative abundances of the chlorine isotopes. The orientation dependent lines show a minimum separation when the axis of the external field is along the crystal axes and is symmetrical to a rotation about the crystal axis with a period of 90°. The over-all width of the spectrum is about 90 gauss. The sodium chlorate spectrum appears to be of the same type as that which appears in sodium nitrate.[1]

* This work supported by a grant from the Research Committee of the University of Alabama.
[1] W. B. Ard, Jr., J. Chem. Phys. **23**, 1967 (1955).

E2. Ferrite Behavior at 7.5 Millimeters and Application to a Unidirectional Wave Guide. JOSEPH H. HADLEY, JR.,* AND ROBERT N. WHITEHURST, *University of Alabama.*—The nonreciprocal rotation of a plane-polarized wave by the Faraday effect can form the basis for a unidirectional transmission line. The rotation may be effected by a ferrite rod mounted coaxially in a cylindrical section of wave guide and magnetized by a steady magnetic field parallel to the length of the rod. A unidirectional wave guide for the 7.5-millimeter band has been built, designed, and tested. Preliminary measurements were made at x-band to provide a basis for "scaling down." The primary work, to be described, involved the measurement of the rotation of the plane of polarization as a function of the applied field for various rod sizes and frequencies. Measurements were also made of standing-wave ratios and of the relative attenuation of the transmitted wave. The results indicate, as theory predicts, that ferrite components have excellent performance at millimeter wavelengths.

* Now at Duke University.

E3. Pure Quadrupole Resonance of Compressed Chlorine Compounds.* W. G. MOULTON, D. L. HOLLIS, AND W. B. ARD, *University of Alabama.*—The effect of pressure on pure quadrupole resonances has been studied previously.[1] We have studied the residual irreversible effect on the resonance after an inhomogeneous compression is removed. The chlorine pure quadrupole resonance has been observed in sodium chlorate, potassium chlorate, and chloral hydrate which have been compressed by the method described by Barr and Mann.[2] The pellets have been prepared by subjecting a powder sample to pressures between 10 000 and 100 000 psi. The resonances are detected by conventional super-regenerative techniques and oscilloscope display. The sodium chlorate resonance shows a decrease in signal amplitude and increase in line width with increasing pressure. This effect is interpreted as being due to the production of crystalline strains. No shift in the resonance frequency of the pellets from that of a powder sample has been observed. The effect is observed only in samples which have been carefully dried. A similar effect, but less pronounced, has been found in potassium chlorate. Work is underway to improve the accuracy by recording the resonances and introducing a method for calibrating the spectrometer sensitivity.

* Supported by a grant from the Research Committee of the University of Alabama.
[1] Kushida, Benedek, and Blombergen, Phys. Rev. 104, 1364 (1956).
[2] E. S. Barr and R. Mann, Bull. Am. Phys. Soc. Ser. II, 2, 284 (1957), this program.

E4. Measurement of Rotational Magnetic Effects.* G. H. MILLER, H. M. PARKER, AND L. RAPPORT, *University of Virginia.*—Apparatus has been developed for the investigation of the effects resulting from the rotation of ferromagnetic samples in a magnetic field. In particular, it is desired to measure rotational hysteresis losses, eddy-current losses, and the effects of magnetic anisotropy. The samples, in spherical form, are held in a plastic holder which is supported in a horizontal magnetic field by a quartz fiber suspension. Two separate measurements are made. In the first, the top plate of the suspension is rotated through measured angles and the resulting angular displacement of the sample is noted. This gives information relative to the anisotropy. In the second type of measurement the amplitude and period of the torsional vibrations are measured as a function of magnetic field for various orientations of the sample in the holder. The materials investigated thus far have been ferrites, chosen so that a very small eddy-current loss is anticipated. The data obtained from the above measurements are presented and discussed. Present instrumental limitations and proposed improvements are noted.

* This work was supported by the Office of Naval Research.

E5. Analysis of System to Measure Rotational Magnetic Effects.* H. M. PARKER, G. H. MILLER, AND L. RAPPORT, *University of Virginia.*—The physical system which is described in the preceding abstract and which has been used to investigate rotational magnetic effects presents an interesting theoretical problem. In the absence of a magnetic field, the system is a damped torsional harmonic oscillator. With a ferromagnetic sample in an applied field, three additional kinds of moments act on the system, namely, (a) a conservative, nonlinear torque related to the anisotropy of the sample, (b) a viscous magnetic damping torque due to the sample and/or sample holder, and (c) a constant magnitude (for a given field strength) damping torque due to rotational hysteresis in the sample. The analysis for the case that the conservative restoring torques are linear is straightforward. Results are presented and the behavior is discussed. The behavior of the system when acted on by an harmonic driving torque is suggested as a means of determining the damping torque. The analysis for the case of nonlinear restoring torque is not readily accomplished. A qualitative discussion of the behavior and the results of an approximate analysis are presented.

* This work was supported by the Office of Naval Research.

E6. Temperature Dependence of the Ratio d_{33}/d_{31} in Polycrystalline Barium Titanate and Lead Zirconate-Titanate. C. V. STEPHENSON, *Alabama Polytechnic Institute,* AND E. G. FRANZAK, *Northwestern University.*—It has been reported by other investigators that the ratio of the piezoelectric constants d_{33}/d_{31} for polycrystalline barium titanate is constant with temperature. If this were true, then the measurement of the temperature variation of d_{33} could be considerably simplified. A study has been made to attempt to verify this fact. It has been found, however, that this ratio is not constant in barium titanate compositions, but may vary by as much as 30% over the temperature range −70°C to +70°C. The ratio was found to be constant in a lead zirconate-titanate composition over this same temperature range.

E7. Electrical Properties of Arsenic-Antimony Selenides.* D. F. CLIFTON AND LEE GILDART, *University of Kentucky.*—Certain mixtures of As_2Se_3 and Sb_2Se_3 readily solidify in the vitreous state, as shown by x-ray diffraction. These vitreous specimens behave as semiconductors with wide energy gap.

* Supported in part by the U. S. Air Force Office of Scientific Research, Air Research and Development Command.

E8. Effect of Elastic Strain on the Electrical Resistance of Magnesium-Indium Alloys. E. W. KAMMER, E. I. SALKOVITZ, AND A. I. SCHINDLER, *Naval Research Laboratory.*—The change in electrical resistance produced by a small elastic strain in an isotropic wire conductor containing lattice imperfections can be expressed by Eq. (1).

$$G=\frac{\Delta R}{R}\Big/\frac{\Delta L}{L}=(1+2\nu)+g_h+\Sigma\frac{P_i}{P_h}g_i. \qquad (1)$$

The term $(1+2\nu)$, where ν is Poisson's ratio, allows for the effect the change in area and length has upon the resistance while g_h is the change in resistivity $\Delta P/P$ per unit elastic strain in the host lattice before the introduction of imperfections. Each term in the summation assigns a similarly defined strain coefficient g_i to the ith type imperfection structure (vacancies, dislocations, alloy component, etc.). An application of Eq. (1) has been made to a substitutional alloy of magnesium containing indium concentrations ranging from 0.446 to 3.01 atomic percent. The experimentally determined values for the ratio G decreased linearly with atomic percent additions of indium. Since the resistivity of each alloy is also known, the coefficient g_i can be computed and was found to have value −0.175.

E9. On the Change in the Weight Distribution Function of Cotton during Storage. W. J. BYATT,* *Kendall Company Research Laboratories* (introduced by A. B. Lewis).—The differential distribution of weight *versus* length for cotton can change with the passage of time due to the presence of damage producing enzymes from various micro-organisms. An equation which governs the time variation of the weight distribution function is derived. It turns out to be an integro-differential equation of exactly the same form as that found by Thompson and Holmes[1] in their discussion of neutron irradiation effects in copper. The solution to the equation is obtained; a numerical example comparing theory and experiment is given. Agreement is satisfactory. I wish to thank the Kendall Company for permission to give this paper.

* Present address: Physics Department, University of Mississippi.
[1] D. O. Thompson and D. K. Holmes, J. Appl. Phys. 27, 713 (1956).

E10. Determination of e/m.* CONRADE C. HINDS AND GERTRUDE FLEMING REMPFER, *Fisk University.*—The importance of the direct determination of the specific charge of the electron will be discussed. Reference will be made to some of the methods of direct measurement of e/m. A new method by which we propose to measure e/m will be described.

* Supported in part by a grant from the Research Corporation.

E11. Electron Microscope Studies of Corroded Surfaces of Metals. HOWARD J. FOSTER AND G. F. REMPFER, *Fisk University.*—Investigations of corroded surfaces of metals are being made by electron microscopy and electron diffraction. The techniques employed in our study will be described. The usefulness of stereo microscopy and diffraction patterns correlated with specimen areas will be discussed.

Invited Paper

E12. Progress in the Energy Band Theory of Solids. JOSEPH CALLAWAY, *University of Miami.* (30 min.)

(DIXON CALLIHAN presiding)

Invited Papers

F1. Civilian Applications of Atomic Energy. PAUL W. MCDANIEL, *U. S. Atomic Energy Commission.* (45 min.)

F2. Physical Foundations for Study of Controlled Thermonuclear Reactions. ARTHUR E. RUARK, *U. S. Atomic Energy Commission.* (45 min.)

Symposium on Nuclear Alignment, Radioactivity, and Parity

(LOUIS H. ROBERTS presiding)

Invited Papers

H1. Atomic and Molecular Consequences of Radioactivity. ARTHUR H. SNELL, *Oak Ridge National Laboratory.* (30 min.)

H2. Orientation of Actinide Group Nuclei. JOHN W. T. DABBS, *Oak Ridge National Laboratory.* (30 min.)

H3. Asymmetric β Emission from Oriented Nuclei. R. P. HUDSON, *National Bureau of Standards.* (30 min.)

H4. Conservation Laws in Beta Decay. M. E. ROSE, *Oak Ridge National Laboratory.* (30 min.)

Astronomy

(WILLIAM CALDER presiding)

I1. Eighteen-Mc Radiation from the Planet Jupiter. T. D. CARR, A. G. SMITH, C. BARROW, AND R. PEPPLE, *The University of Florida.*—A radio telescope consisting of eight half-wave dipoles and a reflecting screen has been designed and constructed for the detection of planetary radiation at a frequency of 18 Mc. Daily records of the sporadic Jupiter noise have been maintained throughout 1957, with both low-speed and high-speed pen recording techniques being used. From the statistical trends which are developing an effort is being made to correlate the occurrence of the noise with various rotational periods, and with possible mechanisms of origin. Supplementary visual and photographic observations of the planet are being made with the new 8-in. Clark refractor.

I2. Calibration of Microwave Radiometers.* ROBERT N. WHITEHURST AND F. H. MITCHELL, *University of Alabama.*—A direct calibration of a microwave radiometer requires two known antenna temperatures and the corresponding scale deflections of the instrument. These deflections may be from hot objects whose temperatures and emissivities are known, or they may be from noise sources whose equivalent temperatures are known. While this is the most straightforward method, it does have disadvantages, particularly in the millimeter wavelength ranges, where calibrated noise sources are often unavailable. Determination of the source temperature from the antenna temperature further requires a knowledge of the antenna pattern, including the side and back lobes. A calibration procedure for small antennas will be described which requires only a single known temperature, obtainable from a microwave absorber at ambient temperature. This method, which requires certain assumptions about the structure of the atmosphere, does not require a knowledge of the side and back lobes of the antenna pattern. Problems introduced by the interchange of antenna and noise source are eliminated.

* Supported by the Office of Ordance Research.

I3. Preliminary Radio Observations of the Moon at 7.5-mm Wavelength.* F. H. MITCHELL, ROBERT N. WHITEHURST, AND JAMES B. DOZIER, JR., *University of Alabama.*—Radiation from the moon has been received on a Dicke-type radiometer. Observations extend over an interval of six months, including the lunar eclipse of November 17–18, 1956. The precision of the lunar data is not high because the instrument was designed for the comparatively large noise power received from the sun. A variation of possibly 30% in lunar temperature would have been measurable, but no variation of this magnitude has been observed. The contribution of the moon to the antenna temperature ranged from 15 to 20°K. By means of a calibration procedure developed for solar temperature measurement, a lunar temperature of about 150°K is indicated. This figure should be considered tentative pending future observations.

* Supported by the Office of Ordnance Research.

I4. Cyanogen Absorption in Cool Stars as an Indication of Age. KENNETH M. YOSS, *Louisiana State University.*—The strength of CN absorption has been measured from microphotometer tracings of objective prism spectra of late-type stars. The spectra of 77 high- and 103 low-velocity stars were obtained with the University of Michigan and the Vanderbilt University telescopes with 4-degree prisms. About 40% of the high-velocity stars definitely have weaker CN absorption than normal, while many of the low-velocity stars have abnormally strong absorption. It is apparent that the high-velocity stars as a group are older stars, based on the Schwarzschild theory, which states that CN absorption depends on the relative abundances of the heavier elements, which in turn depend on age. A variation in age within the high-velocity group is suggested by the fact that the mean velocity and the velocity dispersion is definitely greater (an indication of greater age) for the stars with weakest absorption. No age variation can be detected by velocity or velocity dispersion differences among the low-velocity stars. The large range in CN absorption in this group probably is due to variation in abundances at the time of formation rather than to an age effect.

I5. Model Atmosphere Calculations. RAYMOND GRENCHIK, *Vanderbilt University.*—The interpretation of stellar spectra requires a knowledge of the temperature and pressure distribution with depth in a stellar atmosphere. The necessary parameters for the calculation of an atmosphere are surface gravity, effective temperature, and chemical composition. The absorption and scattering processes must be taken into account in a mass extinction coefficient. Some sources of extinction are neutral hydrogen, negative hydrogen ions, helium, metals, and electrons. Fortunately, in any one particular atmosphere, only one or at most two of these processes must be calculated. The assumption that energy transport is by radiation gives a first approximation of temperature distribution and the solution of the hydrostatic equilibrium produces the pressure variation with depth. The atmosphere requires a constancy of energy flux with depth; otherwise, a correction to the original temperature distribution is applied and the calculation repeated. In very hot stars the hydrostatic equilibrium equation must be corrected with a radiation pressure term. High-speed electronic computing machines are proving highly successful in the calculation of a variety of atmospheres for various combinations of the initial parameters.

I6. Blanketing Effect in the Sun. THOMAS L. SWIHART, *University of Mississippi* (introduced by A. B. Lewis).—Previous work has indicated a discrepancy between observations of the wavelength distribution of the emitted solar continuum and that predicted from theoretical solar atmospheres. The blanketing effect, a possible source of this discrepancy, is investigated in some detail. A self-consistent solar atmosphere with a blanketing coefficient which varies with depth is constructed. The resulting change in the predicted radiation field is entirely too small to explain the above-mentioned discrepancy, although it is in the desired direction.

I7. Three-Color Photometry of the Ultra-Short Period Variable DY Pegasi. DON GEILKER, *Vanderbilt University.*—The intrinsic variable star DY Pegasi, which undergoes a complete pulsation in a period of 105 minutes, was investigated in the uvb system of three-color photoelectric photometry. At the Arthur J. Dyer Observatory a total of 1600 measures of its brightness were obtained, distributed equally in the yellow, blue, and ultraviolet spectral regions. From these observations light curves were constructed which showed a variation of about 0.56 magnitude in the visual region and one-tenth magnitude greater in the blue and ultraviolet. Apparent temperature changes from 8100 to 7300 K° during the cycle (corresponding to spectral class variation from *A*7 to *F*1) were inferred from the b-v color index. This compares with *A*3 to *A*9 derived by Bidelman from slit spectrograms showing anomalous features at all phases. The u-b index remained substantially constant throughout the cycle.

I8. Structure of the Milky Way. I. A. J. Dyer Observatory Research Program. CARL K. SEYFERT AND ROBERT H. HARDIE, *Vanderbilt University.**—Some of the nearest associations of high-luminosity stars which outline the spiral structure of the Milky Way are being investigated at the Dyer Observatory of Vanderbilt University with the 24-inch Baker-Schmidt telescope. Spectra of the stars in each field are obtained with a 24-inch objective prism; and a photoelectric photometer which incorporates a 1-*P* 21 photomultiplier is used to determine the magnitudes of the stars in ultraviolet, blue, and yellow light. The photoelectric colors thus obtained make it possible to derive the absorption by dust and gas between the observer and the stars. When combined with intrinsic luminosity data from other sources, the photometric data make it possible to derive accurate distances for each of the stars in the association, and hence to the spiral arm in which the association is located. At present the work on one association is completed (in Gemini), two nearly completed (in Perseus and Lacerta), and the work on three more is in progress. Results from two of these associations will be reported in the following paper.

* Program supported by the National Science Foundation.

I9. Structure of the Milky Way. II. Stellar Associations in Gemini and Lacerta. ROBERT H. HARDIE AND CARL K. SEYFERT, *Vanderbilt University.**—Some forty *B* stars in the region of the *I* Geminorum association having known spectral types and luminosities were studied by three-color photometry at the Arthur J. Dyer Observatory. Individual distances for these were deduced, and a Hertzsprung-Russell diagram was constructed. A mean distance of 1500 parsecs was found, although there appears to be some evidence of two separate groupings at 1200 and 2100 parsecs. If real, these latter groupings coincide with two spiral arms of the galaxy. In the Lacerta association region, about 85 stars ranging in type from *B*7 to *A*7 were studied. Spectral types were derived from objective prism plates. Three-color photometry on all stars was carried out so that a Hertzsprung-Russell diagram could be constructed. It appears that the *B*7 to *A*0 stars have a mean distance consistent with that of the early *B* stars studied by Harris. The *A*1 to *A*7 stars, however, appear to have different distances, suggesting that they are foreground objects. Thus, the association may have only stars of types *A*0 and earlier. Additional work in this area is in progress by the investigators.

* Work supported by a grant from the National Science Foundation.

Astronomy

(CARL K. SEYFERT presiding)

Invited Papers

J1. Astronomy in Germany. ARNE SLETTEBAK, *Perkins Observatory, Ohio Wesleyan University.* (30 min.)

J2. Astronomy in Russia. NANCY ROMAN, *Naval Research Laboratory.* (30 min.)

J3. Astronomy in South Africa. JOHN IRWIN, *Indiana University.* (30 min.)

Contributed Papers

J4. University of Florida Student Observatory. GUY C. OMER, JR., *University of Florida.*—A new student observatory went into use at the University of Florida with the Fall Semester of 1956. It is a 16 ft×30 ft concrete block and brick building with a roll-off aluminum roof. It contains two piers and will eventually house two telescopes. The first telescope, which is now in service, is an 8 in. refractor which was the generous gift of Mr. Richard Ernst Schmidt of Chicago, Illinois. The optics are by the Clarks, while the mount is by Gaertner and is of the classical German equatorial design. The second telescope will be a 10½-in. reflector of *f*:8 in a mount now being fabricated by the shops of the Department of Physics. The mirror is the gift of the widow of Dr. Fred Heath, late of the University of Florida.

J5. Effects of Long Air Paths on Photographic Resolution.* A. G. SMITH AND M. L. VATSIA, *The University of Florida.*—A series of especially prepared targets has been photographed at distances varying from a few feet to half a mile over several horizontal outdoor ranges. The effect of turbulence on photographic resolving power has been analyzed, and some interesting trends have been established. Exposure time, as a parameter, has been shown to be significant in determining resolution at the shorter ranges, but relatively unimportant at the longer distances.

* Supported by the Office of Ordnance Research.

J6. Experiment to Help Determine the Excitation Process in the Sodium Twilight Flash.* C. DEWEY COOPER, *University of Georgia.*—During twilight a layer of sodium in the upper atmosphere emits the 5890 A yellow line. This radiation may be attributed to resonant scattering of sunlight or it may result from chemical recombinations. If the 5890 A line is produced by resonant scattering, then we may use known transition probabilities and compute the relative intensity of the second member of the resonant series at 3300 A. These calculations have been made and will be discussed. They show that the ultraviolet line should have 1/30 of the intensity of the yellow line. This intensity level should be observable, by spectrographic means, from sodium clouds that can be placed in the upper atmosphere with the aid of rockets. Yellow radiation from such sodium clouds has been observed to be 3000 times stronger than the ordinary twilight flash. One experimental test has failed to produce the predicted ultraviolet line; other tests are planned.

* This work was supported by the Air Force Cambridge Research Center.

J7. Photoelectric Comparison of the Reflectivity of the Moon with that of Magnesium Carbonate Blocks. W. A. CALDER, *Bradley Observatory, Agnes Scott College.*—Widely quoted values of reflecting properties of the moon (albedo, 0.07; reflectivity, 0.12) are based upon an analysis of data as of 1916 by Russell. Because of the bearing upon the visibility of artificial satellites, and upon research proposals for Project Vanguard, a redetermination of the average lunar reflectivity has been in progress at Bradley Observatory for the past three years. Because of the severe requirements of atmospheric transparency, day and night, results are tentative but strongly indicate that the moon may not be as black as has been assumed, perhaps by a factor of two. Technique consists of comparing the surface brightness of a large portion of the moon with that of a $MgCO_3$ block illuminated by the sun, using an intermediary comparison lamp, and reducing observations to a common altitude of sun and moon. The photometer was described in Am. J. Phys. **24**, 529 (1956).

J8. On the Historical Background of Purkinje Effect. KAREL HUJER, *University of Chattanooga.*—Purkinje effect states that the change in the intensity of light is accompanied by a relative change in the perception of color. J. E. Purkinje, in the earliest part of his scientific activity, touched upon the field of physics in this significant phenomenon. The idea was essentially contained in his first paper "Beitrage zur Kenntnis des Sehens in subjektiver Hinsicht," published in Prague, 1819. The second paper in 1823, on a similar topic, not only was his habilitation work for Breslau University but was also dedicated to Johann W. Goethe. It is little known that the Weimar poet spent the last 40 years of his life in a passionate study of the origin of colors. Goethe's views opposed those of Isaac Newton based on the mechanistic behavior of matter in the external world. Goethe in his "empirical idealism" maintained that the sense-perceptible world-picture including color vision is the sum-total of metamorphosing percepts without any underlying matter. Purkinje's two papers appear to be in support of Goethe's ideas and the Weimar poet refers to this fact at several occasions. So far, Goethe's optical ideas have had only historical value and time will show, as the recent views of Jeans, Eddington, Dingle, and others indicate, that Purkinje's work was not a mere expression of gratitude of an admirer but was actually a first step which is bound to reveal that there is some value in Goethe's startling views on the nature and origin of colors. This is due to the fact, as A. Tschermak-Seysenegg, one of the greatest Purkinje scholars has shown, that J. E. Purkinje can be described as the founder of exact subjectivism.

Spectroscopy

(E. SCOTT BARR presiding)

K1. Improved Procedures for the Preparation of KBr Pellets for Infrared Spectroscopy. E. SCOTT BARR AND R. A. MANN, *University of Alabama.*—Technique modifications leading to a simplified die and a desirable pressing procedure for making transparent KBr disks suitable for spectroscopic studies have been evolved. These are associated with the

practical use of relatively low pressures. A hydraulic press capable of a total force of 20 000 pounds was found suitable. Since disks of 0.50-inch diameter were being formed, the corresponding relatively low maximum stress made possible the use of commercial tool steel (such as the Carpenter "No. 11 Special") for the die without special hardening. This in turn made the production of satisfactory dies much simpler and much less expensive. It was found that the pressure needed for a satisfactory KBr pellet varied markedly with temperature. Where 92 000 psi was needed at room temperature, an equally good if not superior pellet could be obtained with only 61 000 psi with the die at about 120°C. The die temperature was achieved simply by keeping it in an oven. Damage to the disk during removal from the die was minimized by: (1) gradual reduction of force on the die; (2) lubrication of the die wall with graphite; and (3) minor modification of die design. The die and pellet production procedure will be described.

K2. Grating Investigation of the Infrared Spectrum of HCOF and DCOF.* ROY F. STRATTON AND ALVIN H. NIELSEN, *The University of Tennessee.*—A preliminary report of the spectrum of HCOF and DCOF[1] was given at this meeting last year. These molecules are accidentally nearly symmetric tops having components of the dipole moments along both the least and intermediate axes of inertia. The absorption regions often appear as widely spaced Q branches superposed on bands with PQR structure. At this time all of the fundamentals have been examined with a grating spectrograph and all except the C−H stretch in DCOF were resolved. A number of overtones and combination bands have also been examined. The analysis of the FCO bend and C−F stretch are complete and the analysis of the planar C−H bending is well begun in both molecules. A slide showing the constants calculated to date will be shown.

* Supported by the Office of Ordnance Research, U. S. Army.
[1] Morgan, Staats, and Goldstein, J. Chem. Phys. **25**, 337 (1956); R. F. Stratton and A. H. Nielsen, Bull. Am. Phys. Soc. Ser. II, **1**, 259 (1956).

K3. Reinvestigation of ν_2 of NO_2. J. W. KELLER* AND A. H. NIELSEN, *The University of Tennessee.*—Using The University of Tennessee prism-grating infrared spectrometer, the fundamental bending vibration ν_2 of NO_2 was reinvestigated, and the difference band $2\nu_2-\nu_2$ was recorded for the first time. The band centers and rotational constants were determined for each band from a rotational analysis performed using combination relations. From the band centers, the anharmonic constant X_{22} was calculated. The line frequencies, rotational constants, and band center found for the ν_2 band were seen to agree very well with previous results, while the value obtained for the anharmonic constant X_{22} differed substantially from the only previously quoted value. In 1953, Gordon E. Moore[1] observed nine overtone and combination bands of NO_2. Using these frequencies, as well as an earlier determination of ν_2, he obtained a complete set of vibrational constants, including $X_{22}=-8.1\pm3.3$ cm^{-1}. The value of X_{22} found in this investigation is -0.6 cm^{-1}. A new set of vibrational constants was determined using Moore's data together with present measurements. Calculated frequencies of bands using this new set were found to agree quite as favorably as those computed from Moore's constants.

* Now at Convair, Fort Worth, Texas.
[1] G. E. Moore, J. Opt. Soc. Am. **43**, 1045 (1953).

K4. Infrared Absorption Spectrum of Chromyl Fluoride.* WILLARD EARL HOBBS, *Union Carbide Nuclear Company.*—The infrared absorption spectra of gaseous chromyl fluoride and gaseous chromyl chloride have been investigated. The region investigated for chromyl fluoride was 2 to 36 microns while that for chromyl chloride was 2 to 25 microns. Six fundamentals and nineteen first overtones or binary combination bands have been observed in the spectra of chromyl fluoride, the fundamentals being located at 274, 304, 727, 789, 1006, and 1016 cm^{-1}. The observed transitions have been assigned on the basis of a tetrahedral model of C_{2v} symmetry. From the observed spectrum it was possible to estimate the probable positions of the three remaining fundamentals. The observed spectrum of chromyl chloride included four fundamentals located at 475, 499, 990, and 1000 cm^{-1} and one first overtone or binary combination band located at 1980 cm^{-1}.

* Based on work performed for the U. S. Atomic Energy Commission by Union Carbide and Carbon Corporation.

K5. Infrared Spectrum of Sulfurylbromofluoride. TERRY TOM CROW, *Vanderbilt University* (introduced by Robert T. Lagemann).—This infrared spectrum of sulfurylbromofluoride has been investigated in the region from two to thirty eight microns using a Perkin-Elmer Model 21 Double Beam Recording Infrared Spectrophotometer. On the assumption that this molecule possessed one plane of symmetry (C_s), an attempt has been made to correlate the data obtained from this study with that in the literature on molecules having a similar structure and composition. Of the nine fundamental modes of vibration, eight have been observed with reasonable certainty. The remaining fundamental has been reasonably well established by this study since there have been indications of its presence and the first overtone of this proposed fundamental has been observed. Twenty-four combination and overtone bands have been explained on the basis of the proposed fundamentals, each of which was used at least three times.

K6. Raman Spectrum of Perchlorylfluoride. J. L. DUNLAP AND ERNEST A. JONES, *Vanderbilt University.*—The Raman spectrum of liquid perchlorylfluoride has been photographed with a Hilger Raman Spectrograph of linear dispersion 16 A/mm at 4358 A. The plates show 26 Raman lines from the mercury parent lines at 4358 A, 4347 A, 4339 A, 4078 A, and 4047 A. The six fundamental vibration frequencies have been assigned and these assignments have been shown to be in agreement with C_{3v} symmetry as reported from infrared studies.

K7. Linear Methods of Interference Optics. ROBERT W. REMPFER, *Fisk University* (introduced by Gertrude Fleming Rempfer and read by title).—The equations giving transmission and reflection data for thin films can be given in a linear approximation. Designs for special purposes (such as selective reflection of certain preassigned wavelengths) can then be given in linear approximation and then corrected. This reports some further work along the same lines, as were previously reported.[1]

[1] Bull. Am. Phys. Soc. Ser. II, **1**, 250 (1956).

Invited Paper

K8. Rotational Distortion in Polyatomic Molecules. HARALD H. NIELSEN, *Ohio State University.* (30 min.)

Nuclear Physics

(J. L. FOWLER presiding)

L1. Energy Distribution of Neutral Pions.* D. T. KING, *The University of Tennessee.*—Nuclear emulsions which had been exposed to the internal 2.7-Bev p^+ beam of the Cosmotron were searched for electron pairs arising from the conversion of energetic γ rays. The quantum energies of the photons, which are due to the decay of neutral pions,[1] were determined from multiple scattering measurements made on the tracks of the electron pairs; it was required that each track measurement be derived from observations on at least 30 independent cells. The energy distribution of the neutral pions was found[2] from the quantum energy distribution of the pairs, and compared to the corresponding energy distribution of the charged pions formed in the same Cosmotron exposure. The results are compared with those expected from a simple kinematic model.

* Supported by the National Science Foundation.
[1] W. E. Crandall and B. J. Moyer, Phys. Rev. **92**, 749 (1953).
[2] R. M. Sternheimer, Phys. Rev. **99**, 277 (1955).

L2. Nuclear Potentials for Light Nuclei with Zero Spin. J. L. FOWLER AND H. O. COHN, *Oak Ridge National Laboratory.*—The neutron differential elastic scattering cross section of O^{16} has been measured at and in the vicinity of the 1-Mev resonance level, as well as at higher nonresonant energies. The s-wave phase shift analysis of this data, together with information on single particle bound state levels in O^{17} and similar data for the C^{13} nucleus allow one to fix the parameters of a potential well which describes the s-wave information.[1] The potentials so determined have a diffuse boundary and are consistent with empirical wells which are found to fit data for higher mass number nuclei.[2] In order to give the energy position of the $d_{\frac{3}{2}}$ unbound state in O^{17} at 1-Mev neutron energy, a spin orbit energy term of the Thomas form is introduced. The factor by which this Thomas term has to be increased is consistent with that found in other work for much higher mass nuclei.[2] A detailed comparison of the $d_{\frac{3}{2}}$ phase shifts calculated with this model will be made with that observed in the O^{16} neutron scattering experiment.

[1] J. L. Fowler and H. O. Cohn, Bull. Am. Phys. Soc. Ser. II, **2**, 32 (1957).
[2] Alex E. S. Green, Phys. Rev. **104**, 1617 (1956).

L3. Angular Distribution of the D(d,n) He^3 Reaction from 200 to 900 kev.* J. C. FULLER, W. E. DANCE, AND D. C. RALPH, *Louisiana State University.*—Angular distributions of $\hat{d}-d$ neutrons have been measured at eight deuteron energies from 200 to 900 kev. The target was zirconium deuterium 300 micrograms cm^{-2} thick cooled by means of an air blast. Neutrons were detected with two plastic scintillators mounted on Du Mont 6292 photomultiplier tubes. One of the counters could be rotated from 0 to 165° with respect to the beam while the other was stationary at 90°, and used as a reference. Data were obtained at twelve angles. Preliminary analysis of the data indicates reasonably good agreement with the recent work of Chagnon and Owen[1] as regards total asymmetry of the angular distribution, and somewhat less asymmetry than that reported by Preston, Shaw, and Young.[2]

* Assisted by U. S. Atomic Energy Commission and Office of Naval Research.
[1] P. R. Chagnon and G. E. Owen, Phys. Rev. **101**, 1798 (1956).
[2] Preston, Shaw, and Young, Proc. Roy. Soc. (London) **A226**, 206 (1954).

L4. Millimicrosecond Time-of-Flight Measurements of (d,n) Neutrons. J. H. NEILER, J. H. GIBBONS, AND W. M. GOOD, *Oak Ridge National Laboratory.*—The millimicrosecond Van de Graaff beam pulsing and multi-channel timing techniques described previously[1,2] have been applied to both kilovolt neutron cross sections[3] and (d,n) neutron spectra and angular distributions. Neutron spectra have been obtained for 1–2.5-Mev deuterons on several of the light elements. Angular distributions have been measured for the neutrons leading to the 3.58-Mev and 5.11-Mev levels of B^{10}.

[1] Neiler, Kelley, and Bell, Bull. Am. Phys. Soc. Ser. II, **1**, 70 (1956).
[2] Good, Neiler, and Gibbons, Bull. Am. Phys. Soc. Ser. II, **1**, 71 (1956).
[3] Gibbons, Good, and Neiler, Bull. Am. Phys. Soc. Ser. II, **2**, 217 (1957).

L5. Beta Decay of N^{16}.* P. W. MORTON† AND H. W. LEWIS, *Duke University.*—The complex beta-ray spectrum of N^{16} has been studied with a magnetic spectrometer[1] to 1% resolution. Pure N^{15} gas contained at atmospheric pressure in a thin-walled (0.003-in.) brass cup ($\frac{1}{2}$-in. diameter×1-in.) was bombarded with 2.6-Mev deuterons to form N^{16} (half-life 7.38 sec). Deuterons entered and beta rays emerged through a 5-micron nickel foil soldered to one end of the cup. Analysis of the spectrum by Kurie plots confirmed the presence of three major groups, with energies of 10.33 ± 0.08, 4.27, and 3.28 Mev. The first group was found to have the unique first-forbidden shape ($\Delta I=2$, yes), confirming the 2^- assignment for N^{16} since the transition goes to the ground state of O^{16}. The corrected Kurie plot, using the unique shape factor a_{11}, is straight above 4.3 Mev, and extrapolation to lower energies permitted the "peeling" of the other two groups, both of which are allowed, from the 10.33-Mev group and from each other. The relative intensities and partial ft values of the groups are, in order of decreasing energy: 24 ± 2, $f_1t=8.2$; 55 ± 4, $f_0t=4.5$; and 21 ± 4, $f_0t=4.4$.

* This work was supported by the U. S. Atomic Energy Commission.
† Now at Mississippi State College.
[1] Reaction product analyzer designed and contructed by O. Meier and R. M. Williamson, Duke University.

L6. Diffusion Cloud Chamber Study of Tritium. L. H. BALL, *University of Mississippi,* (introduced by A. B. Lewis).—A diffusion cloud chamber of approximately 1000 cubic inches volume had been built at the University of Mississippi. The lower plate is cooled by an acetone-dry ice mixture circulated by a centrifugal pump by means of which temperatures below −60°F can be easily reached. Tritiated water in a methanol-water mixture was introduced into the chamber at one-tenth atmosphere and approximately 700 nonstereoscopic photographs of the β decay of tritium were taken. These yielded some 3700 usable β tracks. A discussion of some details of the cloud chamber and of the energy distribution of the β spectrum of tritium will be given.

L7. Equilibrium Charges of Uranium-235 Fission Fragments in Gases as Functions of Fragment Velocity, Gas Pressure, and Type of Gas. CLYDE B. FULMER, *Oak Ridge National Laboratory.*—Equilibrium charges of light and heavy fission fragments of uranium-235 have been determined in hydrogen, helium, air, and argon for a wide range of fragment velocity and gas pressure. The charges were determined from HR values measured by magnetic analysis. Fragment charge was found to vary linearly with velocity within 2% for hydrogen, helium, and air, and within 5% for argon. The maximum pressure effect increases light and heavy fragment charges by 17% and 11%, respectively. Measurements of fragment charges as functions of type of gas agree with the measurements of Lassen.[1] From HR vs (pressure×velocity) data, $\delta\times(\sigma/\pi a_0^2\times10^{-11})$ is estimated to be 4.5, 4.0, 47, and 50 seconds respectively for light fragments in hydrogen, helium, air, and argon, where δ is the mean radiative lifetime for excited electron states of the fragments and σ is the cross section for electron-capture or electron-loss.

[1] N. O. Lassen, Kgl. Danske Videnskab. Selskab, mat-fys. Medd. **25**, No. 5 (1951).

L8. Cross Sections for Dissociation of Diatomic Hydrogen Ions. C. F. BARNETT, *Oak Ridge National Laboratory.*—The total cross sections for dissociation of the diatomic hydrogen ion have been measured in the energy range of 500 kev to 2.25 Mev. The ion beam from the 3 Mv ORNL Van de Graaff was passed through a differentially pumped gas cell, the pressure of which was sufficiently low to prevent multiple collisions. Target gases studied were hydrogen, helium, nitrogen, and argon. For target gases of hydrogen and helium the cross section can be approximated as varying inversely as the square root of the energy. The cross section is smallest for hydrogen being 4.15×10^{-17} cm²/gas atom at 500 kev and decreasing to 2.12×10^{-17} cm²/gas atom at 2.25 Mev. For the heavier gases nitrogen and argon the cross sections decrease only 15–20% throughout the energy range. The dissociation reaction may proceed either by simple dissociation, (i.e., $H_2^+ + A \rightarrow H^+ + H + A$) or by an ionization type dissociation (i.e., $H_2^+ + A \rightarrow H^+ + H^+ + A + e$). Measurements indicate that for a target gas of hydrogen, 50% of the reactions result from simple dissociation, while for argon the percentage decreases to 33. These percentages are independent of the molecular ion energy in the energy interval studied.

Invited Papers

L9. X-Ray Production by Protons. HAROLD W. LEWIS, *Duke University.* (30 min.)
L10. Heavy Ion Induced Nuclear Reactions. A. ZUCKER, *Oak Ridge National Laboratory.* (30 min.)

(DIXON CALLIHAN presiding)

Twenty-Third Anniversary Dinner

Welcome: Vice-President L. M. CHAMBERLAIN, *University of Kentucky*
Address: Science and Society. JOHN R. DUNNING, *Columbia University*

Theoretical Physics

(A. P. FRENCH presiding)

P1. Plasma Losses by Fast Electrons in Thin Films. R. H. RITCHIE, *Oak Ridge National Laboratory.*—The angle-energy distribution of a fast electron losing energy to the conduction electrons in a thick metallic foil has been derived assuming that the conduction electrons constitute a Fermi-Dirac gas and that the fast electron undergoes only small fractional energy and momentum changes. This distribution exhibits both collective interaction characteristics and individual interaction characteristics, and is more general than the results obtained by other workers. Describing the conduction electrons by the hydrodynamical equations of Bloch, it has been shown that for very thin idealized foils energy loss may occur at a value which is less than the plasma energy, while as the foil thickness decreases below $\sim v/w_p$ the loss at the plasma energy becomes less than that predicted by more conventional theories. The net result is an increase in the energy loss per unit thickness as the foil thickness is decreased.[2] It is suggested that the predicted loss at subplasma energies in thin foils may correspond to some of the low-lying energy losses which have been observed by experimenters using thin foils.

P2. Hydrodynamic Calculation of Spontaneous Fission Gamow Factor for $Z>100$. W. D. FOLAND AND R. D. PRESENT, *The University of Tennessee.*—Attempts have been made to calculate spontaneous fission lifetimes from the liquid drop model in which the Gamow integral over the nuclear coordinates is transformed into an integral over the deformation parameters a_n of the drop (whose surface is given by $r = R\Sigma a_n P_n(\cos\Theta)$). This transformation requires evaluation of the kinetic energy in terms of a_n and $\dot{a}_n$. Assuming irrotational motion, the velocity potential is expanded in spherical harmonics and the coefficients are related to the a_n and $\dot{a}_n$. Previous calculations have been incomplete or incorrect.[1,2] For elements sufficiently close to instability ($Z>100$), the barrier corresponds to small values of the a_n, thus justifying series expansions. We neglect all parameters but a_2 and evaluate the kinetic and potential energies through terms in a_2^4. Preliminary results will be reported.

[1] Present, Reines, and Knipp, Phys. Rev. 70, 557 (1946) (electrostatic calculations incorrect).
[2] S. Frankel and N. Metropolis, Phys. Rev. 72, 914 (1947) (hydrodynamic calculations incorrect).

P3. Proton Potential Anomaly for Mirror Nuclei.* P. C. SOOD AND A. E. S. GREEN, *Florida State University.*—The proton potential well is required, in a number of recent studies, to differ from the neutron well by an attractive potential factor in addition to the repulsive Coulomb interaction. The origin and the characterization of this proton potential anomaly is as yet not established. Since the usual Hamiltonians for a mirror nuclei pair differ by the Coulomb energy of the last proton only, one might readily obtain an estimate of the anomaly in this region. The exchange correction factor is introduced based on a study with harmonic oscillator wave functions. This factor is independent of the only unknown parameter $a=(2\pi\omega/h)^{\frac{1}{2}}$ in the oscillator wave functions. The calculated values of the Coulomb energy differences based upon diffuse boundary wave functions and including exchange effects are compared with the experimental results on the assumption of the charge independence of nuclear forces. Closed shell effects are exhibited at $A=4$, 16, and 40. The results point to the absence of any attractive proton anomaly in this region and thus put in doubt the characterization of the anomaly as being proportional to the Coulomb potential throughout the entire region. Its significance with regard to the other characterizations is discussed.

* Supported by a grant from Research Corporation.

P4. Nuclear Self-Consistent Field Calculation.* N. V. V. J. SWAMY AND A. E. S. GREEN, *Florida State University.*—A few self-consistent field calculations have been attempted for the nucleus by others. Talman investigated the problem using a Yukawa force as the two-body interaction and went through one complete cycle in the self-consistent field treatment. His results indicate that successive cycles would eventually lead to nuclear collapse. This point was clarified using a more realistic nuclear density obtained from phenomenological studies. The mutual influence of the two-body force range and the well depth was also investigated. It is hoped that the inclusion of a repulsive core would not only prevent nuclear collapse but also provide a fairly reasonable approximation to the self-consistent field solution of the nuclear problem. A suitable repulsive core is chosen such that the two-body poten-

tial is of the form

$$\frac{a\exp(-k_1|\mathbf{r}-\mathbf{r}'|)}{|\mathbf{r}-\mathbf{r}'|}-\frac{b\exp(-k_2|\mathbf{r}-\mathbf{r}'|)}{|\mathbf{r}-\mathbf{r}'|}.$$

Efforts are being made to carry through the self-consistent field calculations with a nuclear potential obtained from the above basic two-body interaction.

* Supported by a grant from the U. S. Atomic Energy Commission.

P5. Beta-Decay Energies According to a Realistic Independent Particle Model of the Nucleus. R. J. WALKER AND A. E. S. GREEN, *Florida State University.*—Beta-decay energies are calculated for series of nuclides of a given mass number for a representative sampling of mass numbers. These calculations are based upon the energy eigenvalues which result from a realistic independent particle model with a diffuse static potential well. These results are compared with corresponding results inferred from experimental data. The results are analyzed and it is concluded that the model gives approximately correct neutron proton balance for stability with nonsystematic discrepancies which can be explained as errors in individual energy eigenvalues. The model also predicts too small of a steepness of the walls of the nuclear particle binding energy surface. The work indicates that velocity dependence would greatly improve the agreement in the parabolic widths of the isobaric sections of the particle binding energy surface. The last neutron shell structure is analyzed with velocity dependence incorporated in the above model and it is concluded that sufficient velocity dependence to correct the deficiencies of the static model destroy the previous agreement with observation of magic numbers associated with large stability. The possibility of readjusting the well parameters to overcome this difficulty is under study.

P6. Threshold Energies for the Production of Elementary Particles. CLOYD O. BEASLEY, JR., AND W. G. HOLLADAY, *Vanderbilt University.*—Calculations for the threshold energies necessary for the production of elementary particles by incident protons, pions, photons, electrons, antiprotons, and K particles have been made for all possible reactions with as many as four reaction products. The validity of the reaction was governed by conservation of the Gell-Mann-Nishijima quantum numbers. Targets included were free nucleons, nucleons in nuclei, and nucleon pairs in nuclei. Slides showing the threshold kinetic energies of the various particles as a function of the total mass of the product particles will be discussed, and comparisons will be made between the threshold energies of the various processes.

P7. The Statistics of π Mesons. W. G. HOLLADAY AND BILLY S. THOMAS, *Vanderbilt University.*—From the prediction of relativistic quantum field theory that integral and half-integral spin particles obey Bose and Fermi statistics, respectively, it is usually assumed that pseudoscalar π mesons obey Bose statistics. No direct experimental evidence has ever been presented to support this assumption. What is needed is a system of two π's of the same charge such that consequences of assuming that the two π's have an antisymmetric wave function can be experimentally checked. The decay of a τ^+ meson in which the π^- can be identified is such a system. Over 200 such τ^+ events have been observed,[1] and the π^- energy and angular distributions have been recorded for these events. These distributions have been compared with distribution functions derived by making a Dalitz-Fabri type analysis of the decay in which it is assumed that the system of two π^+'s has odd angular momentum. If the spin of the τ^+ is less than three, the data strongly indicate that π mesons are bosons. If the τ^+ meson turns out to have spin zero, the conclusion holds even if parity is not conserved, or if the τ^+ is not a state of definite parity.

[1] See Orear, Harris, and Taylor, Phys. Rev. 102, 1676 (1956) for complete references to the data.

Invited Papers

P8. Nuclear Models and Nuclear Structure. KEITH A. BRUECKNER, *University of Pennsylvania.* (30 min.)

P9. The Capabilities of the Independent Particle Model of the Nucleus. ALEX E. S. GREEN, *Florida State University.* (30 min.)

Divisions of the American Physical Society

Here follow brief statements about the fields of interest and the activities of the five Divisions of the American Physical Society, mainly prepared by the respective Secretaries. All of the Divisions organize symposia and provide invited papers at occasional meetings of the Society or at meetings of their own; most of them issue announcements of their own. Any member of the Society may join each and any Division on payment of an initiation fee of two dollars. Notification of desire to join, and the amount of the initiation fee, must be sent to the Secretary or Secretary-Treasurer of the Division, and *not* to the office of the Society.

Division of Electron Physics

Founded 1943

The object of the Division of Electron Physics is the advancement and dissemination of knowledge associated with the flow of electricity across boundaries and through vacua, gases, and solids. To this end the Division sponsors sessions at the meetings of the American Physical Society and cooperates with other organizations in meetings that lie within its scope. Typical services rendered by the Division are the issuance (by its Secretary) of periodic announcements of activities that it sponsors and distribution of abstracts of papers that it invites to be given at the meetings.

Lately the Division of Electron Physics has chosen the June meeting—more precisely, the Summer Meeting in the East—of the American Physical Society for most of its major programmes.

The Secretary of this Division is V. L. Stout, General Electric Research Laboratory, P.O. Box 1088, Schenectady, New York.

Division of High-Polymer Physics

Founded 1944

The stated object of the Division of High-Polymer Physics is the advancement and diffusion of knowledge of the physics of high-polymeric materials of any kind. Embraced by the interests of the Division are the mechanical, optical, acoustical, and electromagnetic properties of polymers of the organic, as well as semi-organic, type in the solid, colloidal, and dissolved states; intermolecular structure and related statistics; and the influence of nuclear radiation and other agents on properties and structure.

Lately the Division of High-Polymer Physics has chosen the March meeting of the American Physical Society for its major programmes.

The Secretary of this Division is W. James Lyons, Textiles Research Institute, Princeton, New Jersey.

Division of Solid-State Physics

Founded 1947

The Division of Solid-State Physics is concerned with theoretical and experimental research pertaining to the physics of the solid state, including such phenomena as magnetic resonance, ferromagnetism, ferroelectricity, and crystal growth; also the physics of metals, semiconductors, phosphors, dielectrics, etc., and the low-temperature physics of solids and of liquid helium.

Lately the Division of Solid-State Physics has chosen the March meeting of the American Physical Society for most of its major programmes.

The Secretary of this Division is Elias Burstein, U. S. Naval Research Laboratory, Washington 25, D. C.

Division of Fluid Dynamics

Founded 1947

The scope of the Division of Fluid Dynamics covers kinetic theory, statistical mechanics, and structure and dynamics of gases, liquids, and other fluids. These fields of physics include: hydrodynamics, dynamics of compressible fluids, shock and detonation wave phenomena, hypersonic physics, rarefied gases and upper-atmosphere phenomena, transport phenomena, magnetohydrodynamics, ionized fluid and plasma flow, plastic flow, boundary-layer and turbulence phenomena, as well as certain basic aspects of fluid dynamics bordering on geophysics, astrophysics, biophysics, and other fields of science.

The Division of Fluid Dynamics contributes papers to the Annual Meeting of other meetings of the Society, and holds separate meetings of its own.

The Secretary-Treasurer of this Division is S. A. Schaaf, University of California, Berkeley 4, California.

Division of Chemical Physics

Founded 1950

The object of the Division of Chemical Physics is the advancement of subjects of chemical interest which depend on modern physical theories or techniques. Its scope comprises chemical binding and valence; chemical kinetics and thermodynamics; optical, dielectric, and magnetic properties of molecules and crystals; molecular spectra and mass spectra; radiation chemistry; isotopic and exchange phenomena; radiochemistry.

The Division of Chemical Physics contributes papers to various meetings of the Society.

The Secretary of this Division is J. R. Platt, Department of Physics, University of Chicago, Chicago 37, Illinois.

Testimonial to Bell Telephone Laboratories

The Council of the American Physical Society has adopted the following resolution, and has directed that it be published in the Bulletin of the American Physical Society *and in* Physics Today.

The Council of the American Physical Society expresses its deep gratitude for the generous way in which Bell Telephone Laboratories permitted its staff member, Dr. Karl K. Darrow, to devote much of his time and skill to his function as Secretary of our Society. The exceptional success with which he fulfills his duties is known throughout the world of physics. Since his retirement from Bell Telephone Laboratories, Karl Darrow has been maintained in his position as Secretary, and the Council hopes that the Society may continue to use his outstanding services for many more years. Bell Telephone Laboratories can look upon this sharing of Karl Darrow's talents with us as one of their valuable contributions to the advance of modern physics.

Communication from the Treasurer

For the information of the members the Treasurer presents the following statements condensed from the report for the year 1956 of Conroy, Smith & Co., auditors, as presented to the Council at Washington on April 24, 1957.

SHIRLEY L. QUIMBY, *Treasurer*

OPERATING INCOME AND EXPENSES ALLOCABLE TO THE YEAR ENDING DECEMBER 31, 1956

Income:				
Membership dues			$184 857.82	
The Physical Review:				
Income:				
Nonmember subscriptions	$119 741.68			
Published articles	156 280.78			
Sale of back numbers	5 237.27			
Membership subscriptions	60 946.00	$342 205.73		
Expenses:				
Cost of production and distribution: 7462 pages to 6694 member and 2868 nonmember subscribers	$292 642.92			
Editorial office	31 544.78	$324 187.70	$ 18 018.03	
Net receipts from dinners and registration fees			1 209.78	
Interest on bonds and savings accounts		$ 4 093.02		
Proceeds from redemption of U. S. Treasury bonds		5 200.00	9 293.02	
Buckley Physics Prize Award Trust			250.00	
Miscellaneous			144.70	$213 773.35
Expenses:				
Office of the Secretary and Treasurer:				
Salaries		$ 7 674.38		
Payroll taxes		140.33		
Traveling expenses of officers of Society		2 398.87		
General office expenses		3 068.03	$ 13 281.61	
American Institute of Physics—collecting dues and subscriptions			14 785.56	
"Bulletin"—Cost of printing and mailing		23 014.02		
Editorial mechanics—A.I.P.		2 970.80		
		25 984.82		
Deduct—Income from subscriptions		4 867.19	21 117.63	
Reviews of Modern Physics—net expense			828.12	
Cost of membership and reduced rate subscriptions in excess of amounts collected therefor:				
The Review of Scientific Instruments		1 573.50		
The Journal of Chemical Physics		3 765.50		
Journal of Applied Physics		7 643.00	12 982.00	
Contribution to Institution of Electrical Engineers for *"Physics Abstracts"*			32 065.00	
Contribution for maintenance and support of American Institute of Physics—10% of all dues collected			18 807.77	$113 867.69
Net income from operations of 1956				$ 99 905.66

BALANCE SHEET AS OF DECEMBER 31, 1956

Assets

Cash in banks:			
Checking account		$160 093.66	
Savings accounts		76 129.73	$236 223.39
Securities—at cost:			
$50 000. United States Treasury, 2¼%, due December 1959–62		$ 50 836.37	
10 000. United States Treasury, Series F, due April 1959		7 400.00	
14 000. United States Treasury, Series K, 2.76%, due May 1967		14 000.00	
30 000. United States Treasury, Series K, 2.76%, due February 1968		30 000.00	
25 000. Federal Land Bank, 3%, due February 15, 1957		25 007.81	
20 000. Federal Home Loan Banks, 3%, due April 15, 1957		20 000.00	
1 000. Baltimore and Ohio Railroad, 1st Mortgage, Series A 4%, due July 1, 1975		850.00	147 094.18
Accrued interest receivable on investments			1 145.00
Deferred charges:			
"The Physical Review"—30-Year Cumulative Index (value of copies on hand)		$ 7 845.61	
Cost of membership and reduced rate subscriptions to various journals for year, 1957, in excess of amounts collected therefor		10 099.50	17,945.11
			$403 407.68

Liabilities and Surplus

Accounts payable:			
American Institute of Physics, Inc.		$ 14 206.05	
Division of Chemical Physics		549.48	$ 14 755.53
Deferred credits:			
Membership dues—year 1957		$140 041.45	
Subscriptions received from members applicable to issues of journals to be published subsequent to December 31, 1956:			
"The Physical Review"	$ 47 148.36		
"Physics Abstracts" and *"Electrical Engineering Abstracts"*	6 793.70		
"Bulletin"	1 553.97	55 496.03	
Subscriptions collected by American Institute of Physics for account of American Physical Society, applicable to issues of journals to be published subsequent to December 31, 1956		812.02	$196 349.50
Surplus at January 1, 1956		$ 92 396.99	
Add: Net income, year 1956		99 905.66	$192 302.65
			$403 407.68

The American Physical Society

OFFICERS OF THE SOCIETY FOR 1957

President	H. D. SMYTH	Princeton University
Vice-President	J. W. BEAMS	University of Virginia
Secretary	K. K. DARROW	Bell Telephone Laboratories (*retired*) (Office at Columbia University)
Treasurer	S. L. QUIMBY	Columbia University
Managing Editor	S. A. GOUDSMIT	Brookhaven National Laboratory

Past Presidents now on Council: W. F. G. Swann, H. A. Bethe, R. T. Birge, and E. P. Wigner.

Elected Members of the Council: John Bardeen, A. O. Nier, F. Seitz, A. M. Weinberg, S. K. Allison, N. F. Ramsey, Walker Bleakney, and W. K. H. Panofsky.

Local Secretary for the Pacific Coast	W. A. NIERENBERG	University of California, Berkeley
Deputy Secretary	W. W. HAVENS, JR.	Columbia University

Please cut along this line

(To be sent to Professor J. W. Mihelich, University of Notre Dame, Notre Dame, Indiana)

I EXPECT to attend the dinner of the American Physical Society at seven o'clock on Friday evening, June 21. My party will comprise persons.

(*Name*).....

(*Address*).....

(If you want your tickets held to the time of the banquet itself, send a check, made out to American Physical Society, for $3.85 per plate.)